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## Geographical information extraction with remote sensing Part III of III - Appendices

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## Appendix A Geographical information extraction with remote sensing

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### A.1 Software packages used

#### Erdas imagine

Use has been made of the Erdas imagine image processing package for this project. Used are the viewer, the interpreter, the vector, the map composer and the classifier module. Most important for the storage of the data was the registration to a common coordinate system which was performed using the ground control points (GCP) and the resampling algorithm within ERDAS. Once the registration was completed the data could be compared, combined and interpreted in the viewer module.

#### ArcInfo

The vector data have been processed by using both ArcInfo and the ERDAS vector module. Since the ERDAS vector format is 100% compatible with the format used by the geographical Information system (GIS) ArcInfo no conversion problem existed.

#### Erdas Orthomax

There are several software packages which can automatically generate Digital Elevation Models out of SPOT-stereo images. At NLR Erdas Orthomax is used. This software package determines corresponding image points by matching procedures, after which the three dimensional coordinates of the points are computed, also using the geometrical satellite orbit information from the file-

header of the SPOT-image. The result can be analysed in a three-dimensional visualisation mode and corrections can be manually applied.

### Hardware

Abovementioned software was implemented on a Silicon Graphics Indigo 2 UNIX workstation with operating system IRIX 5.2. and a 21 inch 24 bit colour monitor. Use was also made of a CalComp Drawing board III digitizer tablet for manual extraction of GIS data. Colour hardcopies are made with a KODAK XL 7700 Digital Continuous Tone printer using the dye sublimation technique, so that most colour levels present in 24 bit digital data could be printed.

## **A.2 TERAS data set**

We present here several Tables for the DIGEST feature and attribute list. In Tables A1 and A2 we summarise the available TERAS data for this list. In Table A3 and A4 the compressed feature list and cross references to the complete DIGEST list is given. Table A5 gives the resolution categories of section 4.6 (main report) for the complete DIGEST list. Tables A6 and A7 give keywords (technical items) relevant to the features and attributes, respectively. In table A8 we give the areas and methods used for the comparison in section 4 (main report), while in Tables A9 - A11 remarks about the comparison for the six sensors are summarised.

### **A.2.1 Available TERAS data**

*Table A1. Available TERAS data for the DIGEST feature and attribute list*

ID	Feature	Points	Line	Area	Remarks
AD010	Power plant				no data
AD030	Substation			X	3 objects
AJ050	Windmill	X			
AL015	Building	X			special buildings
AL020	Built-up area	X	X	X	build-up areas and isolated buildings
AL070	Fence		X		
AL260	Wall				no data
AL240	Tower	X			
AF010	Chimney	X			
AF030	Cool. Tower				
AF040	Flare Pipe	X			1 object
AT080	Comm. Tower	X			26 objects
AM280	Water Tower	X			3 objects
AN010	Railroad		X		
AP020	Interchange				no data
AP030	Road	X	X		
AQ040	Bridge				no data
AQ045	Bridge Span	X			not complete
AQ065	Culvert	X			
AQ116	Pumping Station	X			
AQ118	Sharp Curve				no data
AQ125	Station	X			

AQ135	Vehicle Stop. Area				no data
AT030	Power Trans. line		X		
AT040	Power Trans. pylon	X			
BB140	Jetty		X		
BG010	Current flow	X			arrow on topographical map
BH020	Canal				no data
BH030	Ditch		X		
BH080	Lake/pond			X	
BH090	Inundation			X	IJssel uiterwaarden
BH100	Moat		X		1 object
BH115	Underground water			X	
BH140	River/stream			X	1 object (IJssel)
BH501	Waterway		X		1 object (Veluwe meer)
BI020	Dam/Weir	X	X		points are weirs/ lines are the IJssel dikes
BI040	Sluice Gate				no data
BI030	Lock	X			2 objects
CA030	Spot Elevation	X			
CA010	Contour line		X		
DA010	Ground Surf. Elem.			X	
DA020	Barren Ground				no data
DB070	Cut				no data
DB080	Depression				no data
DB090	Embankment		X		dikes with (rail)roads etc.
DB501	Upper Part of Cliff		X		
DB010	Cliff				no data
EA010	Cropland			X	
EA020	Hedgerow				no data
EA040	Orchard/Plantage			X	
EB020	Scrub/Brush			X	in this case heath
EC030	Trees		X	X	not complete
FA000	Admin. Boundary		X		
FA001	Admin area			X	
FA015	Firing Range				no data
FA165	Training Area			X	

Table A2. TERAS data for features not included in the DIGEST list.

AK170	Swimming Pool			X	
AL030	Cemetery			X	
AP050	Trail		X		
AQ050	Bridge Superstructure	X			moving bridge
ZB020	Benchmark	X			
ZB060	Geodetic Point	X			

## A.2.2 The compressed feature list

Table A3. Compressed feature list and cross reference to the DIGEST feature list.

Class	Code		Name	DIGEST code's
<b>A</b>	Ap1	point	bridge	AQ045/AQ040/AQ050
Infrastructure	Ap2		culvert	AQ065
	Ap3		stopping area	AQ135
	Ap4		tower	AJ050/AL240/AF010/AF030/AF040/AT080/AM280
	Ap5		building/complex	AL015/AL020P/AQ116/AQ125/AD010
	Ap6		pylon	AT040
	Al1	line	fence	AL070
	Al2		railroad	AN010
	Al3		road	AP030/AP020/AQ118
	Al4		high tension line	AT030
	Aa1	area	substation	AD030
	Aa2		build-up area	AL020L/AL020A
<b>B</b>	Bp1	point	lock/weir	BI020P/BI030/BI040
Hydrography	Bl1	line	jetty	BB140
	Bl2		canal	BH020/BH030/BH100/BH140
	Bl3		dam	BI020L/DB090
	Ba1	area	lake/ponds	BH080
	Ba2		inundation	BH090
<b>E</b>	Ea1	area	barren ground	DA020
Vegetation/soil	Ea2		cropland	EA010
	Ea3		heath	EB020
	Ea4		hedge row	EA020
	Ea5		orchard	EA040
	Ea6		trees	EC030L/EC030P

Table A4. Remaining list not suitable for comparison with RS data

<b>X</b>	Xp1	point	current flow	BG010
Miscellaneous	Xp2		spot elevation	CA010
	Xp3		cut	DB070
	Xl1	line	waterway	BH501
	Xl2		contour line	CA010
	Xl3		cliff	DB010
	Xl4		upper part of cliff	DB501
	Xl5		admin boundary	FA000
	Xa1	area	underground water	BH115
	Xa2		ground surf. element	DA010
	Xa3		depression	DB080
	Xa4		admin area	FA001
	Xa5		firing range	FA015
	Xa6		training area	FA165

### A.2.3 Resolution categories for the DIGEST feature list

In section 4.6 of the main report we introduced resolution categories indicating the lowest possible resolution for detection and recognition. In section 4.6 we have shown these categories for the compressed list. We now give them for the complete DIGEST feature list. For clarity we list the categories here:

- + = extremely low (> 50 m)
- ++ = very low (15-50 m)
- +++ = low (8-15 m)
- ++++ = high (3-8 m)
- +++++ = very high (1-3 m)
- ++++++ = extremely high (<1 m)

Table A5. showing resolution categories which are recommended for detection and recognition.

ID	Feature	Resolution category	
		detection	recognition
AD010	Power plant	++	+++
AD030	Substation	+++	+++++
AJ050	Windmill	++++	+++++
AL015	Building	+++	++++
AL020	Built-up area	+	++
AL070	Fence	+++++	+++++
AL260	Wall	+++++	+++++
AL240	Tower	++++	+++++
AF010	Chimney	++++	+++++
AF030	Cooling Tower	++++	+++++
AF040	Crane	++++	+++++
AF070	Flare Pipe	++++	+++++
AT080	Commun. Tower	++++	+++++
AM280	Water Tower	++++	+++++
AN010	Railroad	+++	+++++
AP020	Interchange	+++	++++
AP030	Road	++	+++
AQ040	Bridge	+++	++++
AQ045	Bridge Span	+++++	+++++
AQ065	Culvert	+++++	+++++
AQ116	Pumping Station	+++	+++++
AQ118	Sharp Curve	+++	++++
AQ125	Station	+++	++++
AQ135	Vehicle Stop. Area	+++	++++
AT030	Power Trans. line	+++++	+++++
AT040	Power Trans. pylon	++++	+++++
BB140	Jetty	+++	++++
BG010	Current flow	-	-
BH020	Canal	++	+++
BH030	Ditch	+++	++++
BH080	Lake/pond	++	+++
BH090	Inudation	-	-
BH100	Moat	+++	++++
BH115	Underground water	-	-
BH140	River/stream	+	++
BH501	Waterway	++	+++

BI020	Dam/Weir	++++	+++++
BI040	Sluice Gate		
BI030	Lock	+++	++++
CA030	Spot Elevation	++++	++++
CA010	Contour line		
DA010	Ground Surf. Elem.	++++	++++
DA020	Barren Ground	+++	+++
DB070	Cut	+++++	+++++
DB080	Depression	++++	++++
DB090	Embankment	++++	+++++
DB501	Upper Part of Cliff	+++++	+++++
DB010	Cliff		
EA010	Cropland	++	+++
EA020	Hedgerow	++++	+++++
EA040	Orchard/Plantage	++	++++
EB020	Scrib/Brush	++	++++
EC030	Trees	++	++++
FA000	Admin. Boundary	+	++
FA001	Admin. Area		
FA015	Firing Range	+++	+++++
FA165	Training Area	++	+++

### A.2.4 Keywords relevant for the features

In section 3 of the Appendix we give a list keywords or technical expressions which play a role in the analysis and interpretation of remote sensing images for the purpose of geographical information extraction.

We give here per feature of the DIGEST list those keywords which we think are important for detection and recognition

Table A6. Keywords (technical items) relevant for detection and recognition.

ID	Feature	Item	Keywords
AD010	Power plant	Detection Recognition	spectral signature, high emission, point target shape, context, infrastructure
AD030	Substation	Detection Recognition	spectral signature, resolution, point target infrastructure, context
AJ050	Windmill	Detection Recognition	spectral signature, resolution, point target resolution, shadow, shape
AL015	Building	Detection Recognition	spectral signature, high emission, point target resolution, shape
AL020	Built-up area	Detection Recognition	spectral signature, high emission, high backscatter. texture, context
AL070 AL260	Fence Wall	Detection Recognition	resolution, shadow, structure shape, structure, resolution, context
AL240 AF010 AF030 AF040 AF070 AT080	Tower Chimney Cooling Tower Crane Flare Pipe Commun. Tower	Detection Recognition	spectral signature, high emission, point target resolution, shadow
AM280	Water Tower	Detection Recognition	spectral signature, high emission, point target resolution, shadow
AN010	Railroad	Detection Recognition	spectral signature, high emission, structure structure, context, point target
AP020	Interchange	Detection Recognition	spectral signature, high emission, low backscatter, structure shape, context
AP030	Road	Detection Recognition	spectral signature, high emission, low backscatter structure
AQ040	Bridge	Detection Recognition	spectral signature, high emission, point target structure, context
AQ045	Bridge Span	Detection Recognition	point target resolution, context
AQ065	Culvert	Detection Recognition	resolution context

AQ116	Pumping Station	Detection Recognition	spectral signature, point target shape, infrastructure
AQ118	Sharp Curve	Detection Recognition	spectral signature, low backscatter shape
AQ125	Station	Detection Recognition	spectral signature, structure structure, infrastructure, context
AQ135	Vehicle Stop. Area	Detection Recognition	spectral signature, low backscatter context
AT030	Power Trans. line	Detection Recognition	point target infrastructure, context
AT040	Power Trans. pylon	Detection Recognition	point target infrastructure
BB140	Jetty	Detection Recognition	spectral signature, high backscatter shape, context
BG010	Current flow	Detection Recognition	context, interferometry context, interferometry
BH020	Canal	Detection Recognition	spectral signature, low reflection, low backscatter structure
BH030	Ditch	Detection Recognition	spectral signature, low reflection, low backscatter structure, context, resolution
BH080	Lake/pond	Detection Recognition	spectral signature, low reflection, low backscatter shape
BH090	Inundation	Detection Recognition	context context
BH100	Moat	Detection Recognition	spectral signature, low reflection, low backscatter structure, context
BH115	Underground water	Detection Recognition	context context
BH140	River/stream	Detection Recognition	spectral signature, low backscatter shape, structure
BH501	Waterway	Detection Recognition	spectral signature, low backscatter context
BI020 BI040	Dam/Weir Sluice Gate	Detection Recognition	point target resolution, context
BI030	Lock	Detection Recognition	point target structure, shape, context
CA030 CA010	Spot Elevation Contour line	Detection Recognition	context, interferometry context, interferometry, stereo

DA010	Ground Surf. Elem.	Detection Recognition	spectral signature, high/low backscatter context
DA020	Barren Ground	Detection Recognition	spectral signature, high emission shape, structure
DB070	Cut	Detection Recognition	resolution, context resolution, context
DB080	Depression	Detection Recognition	context, interferometry context, interferometry
DB090	Embankment	Detection Recognition	structure structure, context
DB501 DB010	Upper Part of Cliff Cliff	Detection Recognition	shadow, context shadow, context
EA010	Cropland	Detection Recognition	spectral signature, high backscatter, structure shape, structure
EA020	Hedgerow	Detection Recognition	spectral signature, structure shadow, structure
EA040	Orchard/Plantage	Detection Recognition	spectral signature, high backscatter texture
EB020	Scrub/Brush	Detection Recognition	spectral signature, high backscatter texture, polarimetry, multi-frequency
EC030	Trees	Detection Recognition	spectral signature, high backscatter texture, shadow, polarimetry, multi-frequency
FA000 FA001	Admin. Boundary Admin. Area	Detection Recognition	context context
FA015	Firing Range	Detection Recognition	resolution, point target resolution, infrastructure
FA165	Training Area	Detection Recognition	spectral signature, point target texture, infrastructure

### A.2.5 Keywords for the attributes

In Table A7 keywords (cf. previous section) important for the attributes present in the DIGEST list are shown. In addition it gives an indication (+, -/+, -) whether remote sensing images are able to give direct information about the attribute.

Table A7. Keywords for the attributes.

ID	Definition	Description	Keyword	Ability of RS
BFC	building function category	type or purpose of the building specified in various categories, e.g. school, house, farm etc. (see FACC <sup>1</sup> ).	shape, context	-/+
CAP	capacity	the capacity of a feature, specified using actual value (unit to be determined).	context	-
DMT	density measure	canopy cover measured by percent within area of feature during the summer season.	resolution, spectral signature, high backscatter	+
DOF	direction of flow	bearing of movement of direction of flow specified in degrees.	context, interferometry	-/+
EXS	existence category	state or condition of the feature specified in various categories, e.g. man-made, destroyed, temporary etc. (see FACC <sup>1</sup> ).	resolution	+
FTI	fence type indicator	type of fence, e.g. metal, wood, stone, rock etc. (see FACC <sup>1</sup> ).	resolution	-/+
HGT	height above surface level	actual value specified in meters.	shadow, stereo, interferometry	+
LC1	load class type 1	military load classification (weight bearing capacity) for one-way traffic for wheeled vehicles. Code is specified according to STANAG 2253.	context, resolution	-/+
LC2	load class type 2	military load classification (weight bearing capacity) for two-way traffic for wheeled vehicles. Code is specified according to STANAG 2253.	context, resolution	-/+
LC3	load class type 3	military load classification (weight bearing capacity) for one-way traffic for tracked vehicles. Code is specified according to STANAG 2253.	context, resolution	-/+
LC4	load class type 4	military load classification (weight bearing capacity) for two-way traffic for tracked vehicles. Code is specified according to STANAG 2253.	context, resolution	-/+
LEN	length or diameter of a feature.	measurement of the dimension of an object, using the longest axis specified in meters.	resolution	+
LTN	track/lane number	the number of tracks or lanes on the feature, including both directions	resolution	+
MCC	material composition category	composition material, excluding surface material, e.g. brick, asphalt etc. (see FACC <sup>1</sup> ).	spectral signature	-/+
NOS	number of spans	number of spans of a bridge or viaduct	resolution	+
OHC	overhead clearance category	the least distance between the travelled way and any obstruction vertically above it.	resolution, context, stereo, interferometry	-/+
PHT	predominant height	height of 51% or more of the feature or the average height expressed in meters	shadow, stereo, interferometry	+

<sup>1</sup> FACC: Feature and Attribute Coding Catalogue

PPT	populated place type	the type of population type, specified as native settlement, shanty town, tent dwellings, other or unknown	texture, structure, context	-/+
RAD	radius of sharp curve	radius of curvature of sharp curves, specified in meters.	shape, resolution	+
RRA	railroad power source	source of electrical power for locomotion, specified as electrified, overhead electrified, non-electrified or others.	context, resolution	-/+
RRC	railroad categories	the type of railroad system used to support various transportation uses (see FACC <sup>1</sup> ). For example, main line, branch line, tramway.	context	-
RST	road/runway surface type	the physical surface composition of a road. For example, hard or loose, paved or unpaved.	spectral signature, emission, low backscatter	+
SCC	spring/well characteristic category	type of available water specified in for example mineral, salt, potable, fresh etc.	context	-
SDS	stem diameter size	the average diameter of trees in a stand, measured at a height of 1.4 m above the ground specified in meters.	context	-/+
SGC	slope/gradient	percentage of slope	stereo, interferometry	+
STP	soil type	soil categories described by the Unified Soil Classification System (USCS). For example, inorganic clays of low to medium plasticity.	spectral signature	-/+
SWC	soil wetness condition	general moisture content or condition of a soil, like dry, moist, wet, frozen or other.	spectral signature, emission, high backscatter	-/+
SWL	single wheel bearing load	the estimated single wheel load (ESWL) expressed in kiloponds.	context	-
TSC	tree space category	the average distance from the centre of one tree to the centre of the nearest tree in a stand.	resolution, texture	+
USE	usage	usage specified in various categories like private, military, agricultural etc (see FACC <sup>1</sup> ).	context	-/+
VEG	vegetation characteristics	type of plant or plantings, like deciduous, coniferous, wheat etc. (see FACC <sup>1</sup> ).	spectral signature, polarimetry, multi-frequency	+
WDA	water depth average	the average water depth expressed in meters.	context	-
WID	width	the shorter length of two linear axes on the horizontal plane, expressed in meters	resolution, shape	+
WVA	water velocity average	average velocity of stream expressed in meters/second	interferometry	-/+
ZV1	lowest Z value	elevation above a given datum to the lowest portion of the feature.	stereo, interferometry	+

### A.2.6 Comparison TERAS and RS data-set - methods and areas

We summarise here the areas and the methods we have used to compare the TERAS and remote sensing data-set for the Heerde test area.

*Table A8. Summary of areas and methods used in the comparison*

ID's	Name	Area	Method
Ap1	bridge	Heerde test area	counting detected objects
Ap2	culvert	upper 50% of Heerde test area	counting detected objects
Ap3	stopping area	Heerde test area	inspection of 2 parking lots
Ap4	tower	Heerde test area	counting detected objects
Ap5	building/com plex	area of Olst from the IJssel and eastward (10 by 2 km)	counting detected objects (about 100)
Ap6	pylon	Heerde test area	counting detected objects
A11	fence	Heerde test area	inspection of a few objects
A12	railroad	Heerde test area	inspection
A13	road	Heerde test area	inspection of the total length for which the object is detected
A14	high tension line	Heerde test area	inspection
Aa1	substation	27 East	counting detected objects
Aa2	build-up area	Olst and surroundings	inspection by using the top50 map
Bp1	lock/weir	Heerde test area	counting detected objects (about 30)
B11	jetty	Heerde test area	counting detected objects
B12	canal	Heerde test area	inspection
B13	dam	Heerde test area	inspection of the total length for which the object is detected
Ba1	lake/ponds	Heerde test area	inspection of several cases
Ba2	inundation	IJssel river basin	inspection
Ea1	barren ground	Heerde test area	inspection by using the top50 map
Ea2	cropland	Heerde test area	inspection
Ea3	heath	27 East and West	inspection
Ea4	hedge row	Heerde test area	inspection
Ea5	orchard	Heerde test area	counting detected objects
Ea6	trees	Heerde test area	inspection

### A.2.7 Comparison TERAS and RS data-set - remarks

We summarise here our remarks about the comparison between the TERAS data-set and RS data-set. This is done for the 6 sensors we have used in Tables A9-A11.

Table A9. Remarks about the comparison between RS and TERAS data - TM and PAN.

ID's	Name	TM	PAN
Ap1	bridge	resolution is too low	low resolution is a problem
Ap2	culvert	resolution is too low	low resolution is a problem
Ap3	stopping area	resolution is too low	only the larger ones can be detected
Ap4	tower	resolution is too low	resolution is too low
Ap5	building/complex	only the larger ones are detected	the smaller buildings are missed
Ap6	pylon	resolution is too low	low resolution is a problem
A11	fence	resolution is too low	resolution is too low
A12	railroad	only the larger ones are detected multi-spectral property is helpful	detection is quite well possible
A13	road	only the larger ones are detected	the smaller ones are not detected
A14	high tension line	resolution is too low	resolution is too low
Aa1	substation	resolution is too low	difficulties in detecting the attributes of the facility
Aa2	build-up area	only the larger areas are detected multi-spectral property is important	low resolution is sometimes a problem.
Bp1	lock/weir	resolution is too low	resolution is too low
B11	jetty	resolution is too low	resolution is on the edge of detection/non-detection
B12	canal	only the larger ones can be detected	difficulties in detecting the (smaller) canals since multi-spectral property is missing
B13	dam	sometimes detected due to the detection of roads and waterways	sometimes detected due to the detection of roads and waterways
Ba1	lake/ponds	only the larger ones can be detected	only the larger ones can be detected
Ba2	inundation	resolution is too low to see textural differences between inundation and surroundings	sometimes the textural differences become apparent
Ea1	barren ground	multi-spectral property is important	is often detected due to the high reflection
Ea2	cropland	multi-spectral property is important	difficulties for detection due to the missing spectral property
Ea3	heath	multi-spectral property is important	detected by the typical shape of these fields
Ea4	hedge row	multi-spectral property is important	these smaller objects are not seen
Ea5	orchard	because of multi-spectral property these objects can be reasonably detected	spectral information is missing
Ea6	trees	only larger parcels of trees can be detected.	the isolated and smaller trees cannot be detected

Table A10. Remarks about the comparison between RS and TERAS data - KVR and CAESAR

ID's	Name	KVR	CAESAR
Ap1	bridge	no real problems for detection	no real problems for detection
Ap2	culvert	the small radiometric resolution is a problem.	combination of multi-spectral property and resolution is helpful
Ap3	stopping area	no real problems for detection	no real problems for detection
Ap4	tower	difficult to detect	difficult to detect
Ap5	building/complex	no real problems for detection	no real problems for detection
Ap6	pylon	detected by the shadow	no real problems for detection
Al1	fence	resolution is in general too low, sometimes context information helps	resolution is too low
Al2	railroad	no real problems for detection	no real problems for detection
Al3	road	no real problems for detection	no real problems for detection
Al4	high tension line	resolution is too low	resolution is too low
Aa1	substation	no real problems for detection	no real problems for detection
Aa2	build-up area	no real problems for detection	no problems for detection
Bp1	lock/weir	missing spectral property is disadvantages	only the larger ones can be detected
Bl1	jetty	no real problems for detection	no real problems for detection
Bl2	canal	the small radiometric resolution is a problem	the smaller ones are difficult to detect
Bl3	dam	often shadow of banks (talud) can be seen	sometimes shadow of banks (talud) can be seen; multi-spectral information is not so important here
Ba1	lake/ponds	the small radiometric resolution is a problem for the smaller objects	for the smaller ones obscuring trees are a problem
Ba2	inundation	textural differences are often apparent	textural differences are often apparent
Ea1	barren ground	missing spectral property is disadvantageous	spectral information is advantageous
Ea2	cropland	missing spectral property is disadvantageous	spectral information is advantageous
Ea3	heath	missing spectral property is disadvantageous	spectral information is advantageous
Ea4	hedge row	missing spectral property is disadvantageous	spectral information is advantageous
Ea5	orchard	missing spectral property is disadvantageous	spectral information is advantageous
Ea6	trees	missing spectral property is disadvantageous	spectral information is advantageous

Table A11. Remarks about the comparison between RS and TERAS data - PHARS and TIR

ID's	Name	PHARS	TIR
Ap1	bridge	in several cases detected by high backscatter	no real problems for detection
Ap2	culvert	difficult to detected; resolution is too low	difficult because of little contrast between ditches and the surroundings
Ap3	stopping area	resolution is a problem	quite dependent on the emission
Ap4	tower	difficult to detected; sometimes high reflections are present, but cannot be distinguished from other surrounding reflections	difficult to detect. Objects are small and easily confused.
Ap5	building/complex	smaller objects are difficult to detect.	can be detected quite clearly
Ap6	pylon	clear reflections from these objects allow detection	difficult to discriminate against the background
Al7	fence	resolution is too low	resolution is too low
Al2	railroad	no real problems for detection	can be detected, but is sometimes difficult to discriminate against the background
A13	road	confusion with canals. The smaller ones are not detected	detection is quite depending on the emission (i.e. temperature differences with the surroundings)
Al4	high tension line	only seen in a few special cases.	resolution is too low
Aa1	substation	no real problems for detection	facilities belonging to the substation are easily detected.
Aa2	build-up area	no real problems for detection	buildings are easily detected.
Bp1	lock/weir	only the larger ones can be seen due to high reflection	difficult too detect against the water, depending on the emission
Bl1	jetty	no real problems for detection	sometimes difficult too detect against the water, depending on the emission
Bl2	canal	only the larger ones are detected	little contrast between ditches and the surroundings
Bl3	dam	sometimes detected as lines where shadow from the banks (talud) can be seen	difficult too detect.
Ba1	lake/ponds	for the smaller objects obscuring trees are a problem	depending on the emission differences between water and land
Ba2	inundation	textural differences are less obvious due to the speckle	textural differences are often apparent
Ea1	barren ground	confusion with vegetated surfaces	only detected when the surface is heated by the sun.
Ea2	cropland	fields can be distinguished quite well	sometimes difficult too detect since the contrast between the fields is low
Ea3	heath	only detected when shape of the fields can be seen	depending on the emission of the heath compared to the surroundings
Ea4	hedge row	the smaller objects are not seen due to the speckle	detected through the low contrasting emission from the shadows.
Ea5	orchard	difficult to detect	difficult to detect
Ea6	trees	isolated trees are difficult to detect due to the speckle	detected through the low contrasting emission from the shadows.

### A.3. Technical reference list

We give here in alphabetical order technical term or keywords which play a role in the analysis and interpretation of remote sensing images for the purpose of geographical information extraction:

- **context:** information about an object is retrieved indirectly using other information or knowledge in addition to remote sensing images. Context is typically essential when remote sensing images do not contain the desired information directly. For example, the proximity of large buildings and water may indicate of a power plant, since it is known that power plants require cooling water. The soil type of a vegetated surface is not directly observable, but the proximity of a river and the type of vegetation may hint at clay using geophysical/biophysical knowledge.
- **detection:** an object or feature can be seen when its location in the image is known (knowledge a priori)
- **high backscatter (*microwave*):** the backscatter is high due to medium level (brush) to high level (forest) vegetation. In the vegetation layer multiple scattering occurs producing a relatively high return back towards the radar.
- **high emission (*thermal infrared*):** used in the case of thermal infrared images. Especially man-made structures can become warm due to solar heating (e.g., roofs). The object will then appear bright in the images due to high thermal emission. Another possibility is excess heat (e.g., from a power plant) giving high thermal emission.
- **identification:** it is possible to retrieve information about the properties of the feature or object. i.e. it can be classified. In this study we restrict ourselves to detection and recognition, because of the limited resolution. Identification usually requires a very high resolution.
- **infrastructure:** collection of man-made objects and features which are apparently related to each other.
- **interferometry (*microwave*):** a technique using two microwave images from almost the same view point in order to measure height or velocity differences.
- **low backscatter (*microwave*):** the backscatter is low, which occurs in the case of a smooth surface. i.e. the roughness is small compared to the wavelength. For example standing water, asphalt etc are smooth for radars using a wavelength of 5 cm.
- **low reflection (*optical*):** reflection of solar radiation in the direction of the sensor is low. This occurs for smooth surfaces (e.g., standing water) when sensor and solar illumination are not properly aligned.
- **multi-frequency (*microwave*):** microwave images are collected at different wavelengths. Since the backscatter properties and transmittance of an object or vegetation are a function of wavelength additional information is obtained. In this way it is, for example, possible to discriminate between high and low vegetation.

- **point target (*microwave*):** a point feature in the image without structure. Especially in the case of microwave images due to double bounce scattering from buildings, towers, etc.
- **polarimetry (*microwave*):** microwave images are recorded using a certain polarisation. In the case of polarimetry a complete set of polarisations is used to obtain 4 independent images. Such a set of images contains more information about the properties of objects and terrain than a single image. Polarimetry is especially advantageous for classification purposes.
- **recognition:** an object or feature can be seen in the image without foreknowledge.
- **resolution:** the minimum distance for which two points in the image can be separated; it should be high enough in order to retrieve the necessary information. For example to identify a windmill the resolution should be sufficiently high in order to detect the vanes.
- **spectral signature (*optical*):** the relative values of reflectivity as a function of wavelength in the optical and near infrared. For example green vegetation has contrary to man-made objects a high reflectivity in the near infrared, which enables distinction in optical imagery.
- **shadow:** dark patches in the image, mostly along the edges of forest.
- **shape:** the outline of an object or feature.
- **stereo (*optical*):** a technique for combining two images with two different viewing angles. Due to perspective distortions elevation of terrain and objects can be determined. Mostly applied using optical imagery, but also possible using microwave imagery. The accuracy depends on the resolution.
- **structure:** both the outline (shape) and the appearance (texture) are of importance.
- **texture:** appearance of an object. For example a build-up area has a typical appearance due to the street pattern.



## **Appendix B Image catalogue**

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B.2	Hardcopies of images.....	2

### **Geographical information extraction with remote sensing**

#### **B.1 Introduction**

As basis for the study we have used a collection of features and attributes, which have been selected as relevant for military terrain inventory. The features and attributes are extracted from a DIGEST (digital geographical information exchange standard) code list. About 60 features are selected covering 6 categories, which are listed here:

1. Culture; which includes typically man-made object like buildings, roads etc (code A).
2. Hydrography; for example rivers, canals, ditches, lakes etc (code B)
3. Relief portrayal; spot elevation, contour lines (code C)
4. Land forms; for example barren ground, depression (code D)
5. Vegetation; for example trees, crop land (code E)
6. Demarcation; e.g., an administrative boundary (code F)

The complete list of features including the attributes is shown in Table 1. In order to assess the ability of the sensors for geographical information extraction we have produced images from the above-mentioned sensors for the features which were available at the so-called Heerde test site (an area of 10 by 20 km between the river IJssel and the Holterberg).

About 40 features were found in the test area and are shown on hardcopies on the following pages with the scale adapted so that the resolution dimension (on paper) is about 0.5 mm. The corresponding scale is indicated on the hard copies. The actual feature is always in the centre of the images. For comparison a topographical map of scale 1:50,000 containing the features is also shown. Next to the hardcopies a concise description for the features with respect to detection and identification for the three wavelengths is given. This information is summarised in section 2 of the Appendix (Tables A6 and A7) where we give keywords for each feature and attribute. These keywords are explained in the technical reference list in section 3 of Appendix A.

## B.2 Hardcopies of images

Index of features shown:	Page
1. AD010 Power plant	B.4
2. AD030 Substation/Tranformator yard	B.6
3. AJ050 Windmill	B.8
4. AL015 Building	B.10
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6. AL070 Fence	B.14
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19. AT030 Power transmission line	B.40
20. AT040 Power transmission pylon	B.42
21. BB140 Jetty	B.44
22. BG010 Current flow	B.46
23. BH020 Canal	B.48
24. BH030 Ditch	B.50
25. BH080 Lake/pond	B.52
26. BH090 Land subject to inundation	B.54
27. BH100 Moat	B.56
28. BH115 Underground water	B.58
29. BH140 River/stream	B.60
30. BH501 Waterway	B.62
31. BI020 Dam/weir	B.64
32. BI030 Lock	B.66
33. CA030 Spot elevation	B.68
34. DA010 Ground surface element	B.70
35. DA020 Barren ground	B.72
36. DB070 Cut	B.74
37. DB080 Depression	B.76
38. DB090 Embankment/fill	B.78
39. DB501 Upper part of a cliff	B.80
40. EA010 Cropland	B.82
41. EA020 Hedge row	B.84

42. EA040	Orchard/plantage	B.86
43. EB020	Scrub/Brush	B.88
44. EC030	Trees	B.90
45. FA000	Administrative boundary	B.92
46. FA015	Firing range	B.94
47. FA165	Training area	B.96

## AD010 Power plant (Electriciteitscentrale)

### Definition:

The buildings and equipment necessary for the generation of electric power

### Detection:

Detection is not difficult because of its dimensions, both from spaceborne as well as airborne systems.

- *Optical*: Buildings show a different spectral signature than water and vegetation and are therefore detected when the dimensions are larger than the resolution.
- *TIR*: Because these complexes emit excess heat, for example in the cooling water, they are easily detected.
- *Microwave*: Especially the high structures will be detected as point targets due to double bounce reflections.

### Recognition:

- *Optical*: Both by means of its shape as well as the (multi-)spectral information recognisable.
- *TIR*: Combination of a large building and excess of heat make recognition possible.
- *Microwave*: Identified by means of a group of point targets near water.

### Attributes:

**HGT** (height above surface level): using stereographic techniques in the optical region or interferometric techniques in the microwave region with sufficiently high resolution. Sometimes possible using an observable shadow.

**LEN** (length/diameter of point feature): possible when the resolution is sufficiently high.

### Examples:

204000, 498025

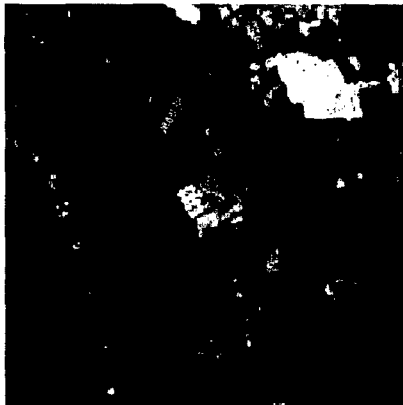
203620, 478717



Landsat TM 18-10-93 1:50.000



KVR 1000 19-5-92 1:10.000



SPOT XS 10-6-92 1:50.000



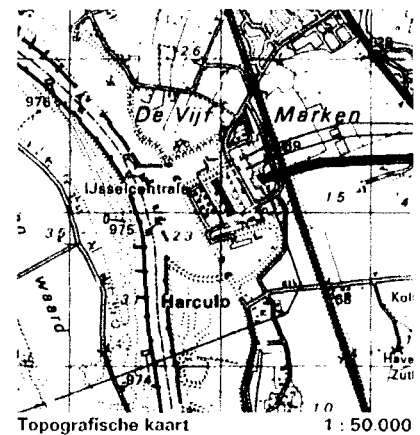
SPOT PAN 13-10-92 1:25.000



ERS 6-8-92 1:100.000



JERS 20-9-93 1:100.000



Topografische kaart 1:50.000

### **AD030 Substation/Transformator yard** (Transformatorstation/verdeelstation)

**Definition:**

A facility, along a power line route, in which electric current is transformed and/or distributed.

**Detection:**

- *Optical*: Detected by means of spectral discrimination between the buildings and the surrounding vegetation for the higher resolution spaceborne (KVR, Spot-PAN and Spot-XS) and airborne data.
- *TIR*: The buildings are detected by possible excess heat or by solar heating in day time.
- *Microwave*: The buildings give reflections which appear as bright targets in the image.

**Recognition:**

Not possible with low resolution spaceborne sensors due to the small dimensions of the objects.

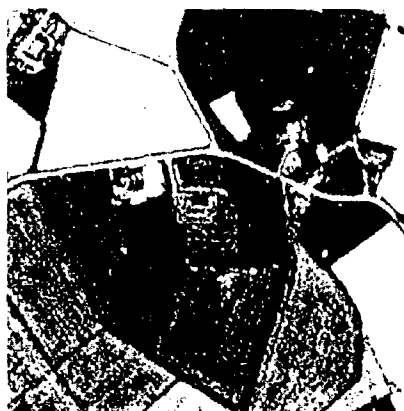
- *Optical*: By means of combination of detected buildings and objects and the field, which is recognised by its border.
- *TIR*: Only possible when most of the objects and buildings are detected.
- *Microwave*: Difficult since the detected point targets do not reveal the purpose of the buildings. The terrain can usually be discriminated from the surroundings.

**Attributes:****Examples:**

205323, 485820



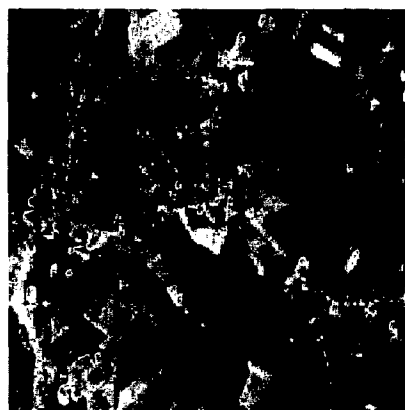
Landsat TM 18-10-93 1:50.000



KVR 1000 19-5-92 1:10.000



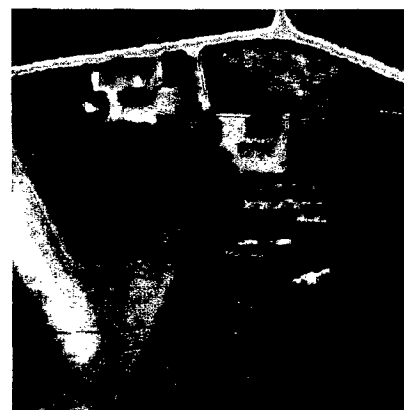
Caesar 3m 22-9-94 1:10.000



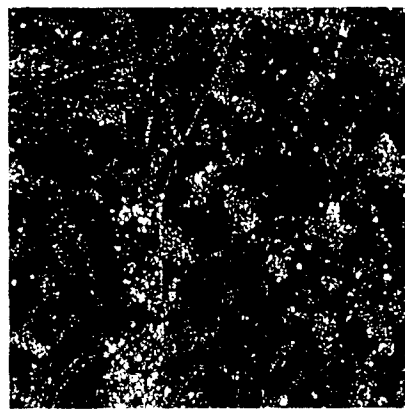
SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



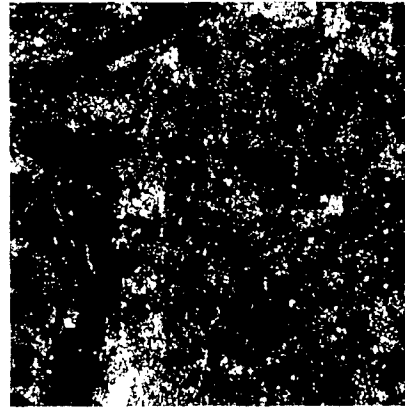
Caesar 1.5m 22-9-94 1:5.000



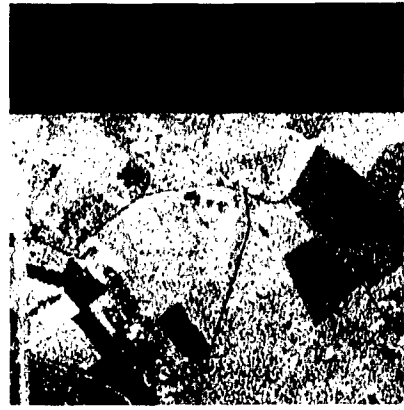
ERS 6-8-92 1:100.000



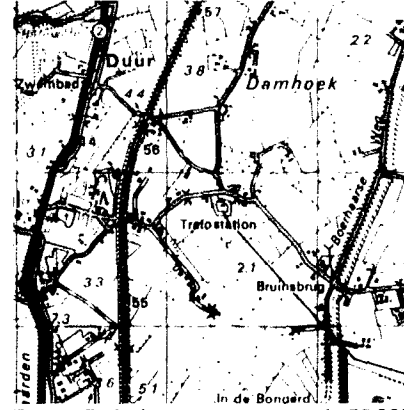
PHARS 27-9-94 1:25.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

**AJ050 Windmill (windmolen)****Definition:**

A wind-driven system of vanes attached to a towerlike structure (excluding wind-generated power plants)

**Detection:**

see AL240

**Recognition:**

Generally not possible and easily confused with towers. Only with high resolution optical data (~ 1 m) it is sometimes possible to identify this object from the shadow of the vanes.

**Attributes:**

**HGT** (height above surface level): using stereographic techniques in the optical region or interferometric techniques in the microwave region with sufficiently high resolution. Sometimes possible using an observable shadow.

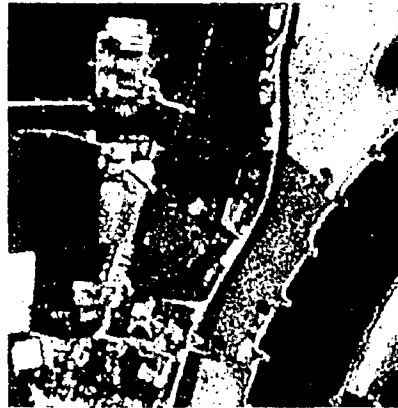
**Examples:**

203090, 483520

200290, 484642



Landsat TM 18-10-93 1:50.000



KVR 1000 19-5-92 1:10.000



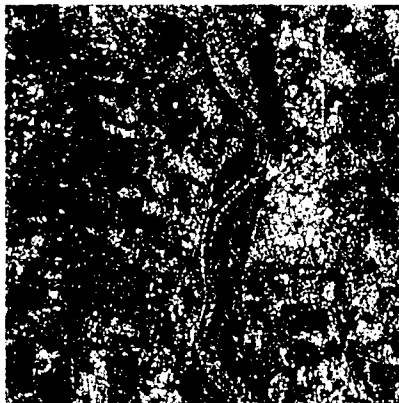
Caesar 3m 22-9-94 1:10.000



SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



ERS 6-8-92 1:100.000



PHARS 27-9-94 1:25.000



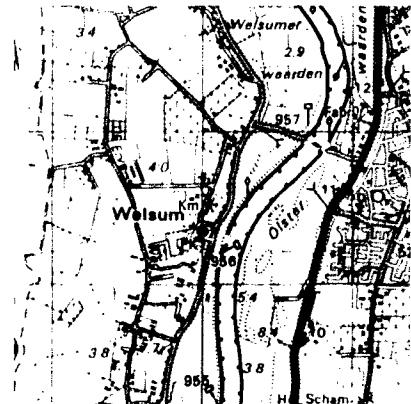
TIR 9/10-94 1:10.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

## AL015 Building (gebouw)

### Definition:

A relatively permanent structure, roofed and usually walled and designed for some particular use.

### Detection:

- *Optical*: Possible on basis of spectral discrimination between the object and its surroundings both for airborne as well as spaceborne data. Only for low resolution spaceborne data (e.g. LandSat) impossible.
- *TIR*: Usually well possible during day time due to solar heating of the roof and when buildings emit heat due to internal heating.
- *Microwave*: Possible with airborne data. With spaceborne data only possible when appropriate reflections (corner reflections) occur.

### Recognition:

- *Optical*: By means of shape and context implying that resolution should be high enough. Therefore not possible for the low resolution spaceborne data.
- *TIR*: By means of the shape of the detected buildings.
- *Microwave*: Possible recognition due to the high radiometric value of the reflections.

### Attributes:

**BFC** (building function category): -

**HGT** (height above surface level): using stereographic techniques in the optical region or interferometric techniques in the microwave region with sufficiently high resolution. Sometimes possible using an observable shadow.

### Examples:

209988, 480368

210355, 484275

206872, 485877

209725, 486725



Landsat TM 18-10-93 1:50.000



KVR 1000 19 5 92 1:10.000



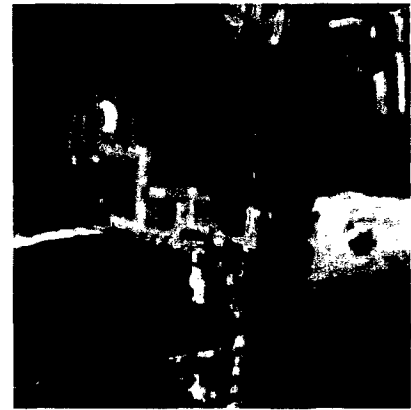
Caesar 3m 22 9 94 1:10.000



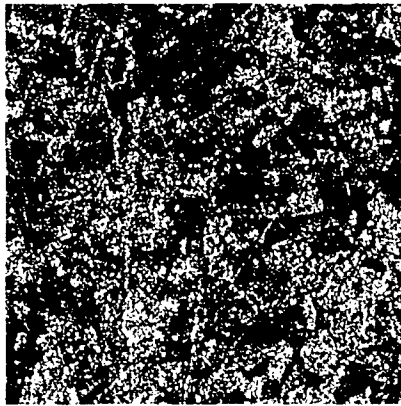
SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



Caesar 1.5m 22 9 94 1:5.000



ERS 6-8-92 1:100.000



PHARS 27 9 94 1:25.000



TIR 9/10-94 1:10.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

## **AL020 Built-up Area (bebouwd gebied)**

### **Definition:**

An area containing a concentration of buildings and other structures.

### **Detection:**

- *Optical*: Both for space- and airborne data possible due the spectral properties as well as texture.
- *TIR*: By means of the detection of individual buildings (see AL010).
- *Microwave*: Possible due to the high number of reflections.

### **Recognition:**

- *Optical*: Well possible by means of the textural appearance (low resolution data) and recognisable street patterns (high resolution) data.
- *TIR*: Well possible when individual buildings are detected.
- *Microwave*: Well possible for both spaceborne and airborne data due to the high reflections and the specific texture. Parts of the area with high structures (industrial areas or flats) stand out quite clearly.

### **Attributes:**

**HGT** (height above surface level): using stereographic techniques in the optical region or interferometric techniques in the microwave region with sufficiently high resolution. Sometimes possible using an observable shadow.

**PPT** (populated place type): possible using context information.

### **Examples:**

207140, 478260

204233, 483345

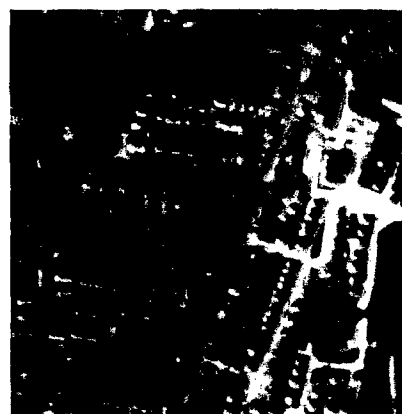
214135, 479007



Landsat TM 18-10-93 1:50.000



KVR 1000 19 5 92 1:10.000



Caesar 3m 22 9 94 1:10.000



SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



Caesar 1.5m 22 9 94 1:5.000



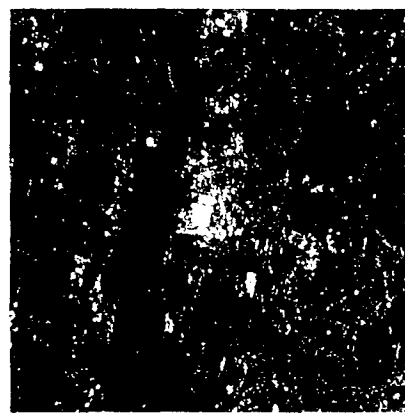
ERS 6-8-92 1:100.000



PHARS 27 9 94 1:25.000



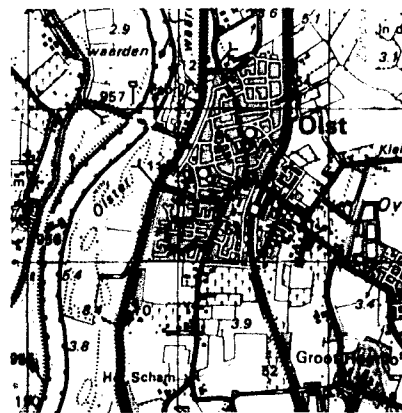
TIR 9/10-94 1:10.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1: 50.000

**AL070 Fence (hek)****Also: AL260 Wall (muur)****Definition:**

A man-made barrier of a relatively light striker (fence) or of solid heavy material (wall) used as an enclosure or boundary or for protection.

**Detection:**

Indirect for both spaceborne as well airborne data by detecting different types of land use which are separated by the fence. The actual fence can only be detected with high resolution (~1 m) data.

- *Optical*: Difference in land use is well detected for both space as well as airborne data.
- *TIR*: Only when the land use is of different type showing different temperatures (e.g., vegetated fields and bare soil fields)
- *Microwave*: With spaceborne data impossible. Airborne data allows detection of different kinds of land use and sometimes detection of a shadow caused by the structure.

**Recognition:**

Only indirect by means of context information.

- *Optical*: Only possible for higher resolution data (< 3 m).
- *TIR*: difficult
- *Microwave*: difficult

**Attributes**

**FTI** (fence type indicator): -

**HGT** (height above surface level): using stereographic techniques in the optical region or interferometric techniques in the microwave region with sufficiently high resolution. Sometimes possible using an observable shadow.

**Examples**

213733, 479015



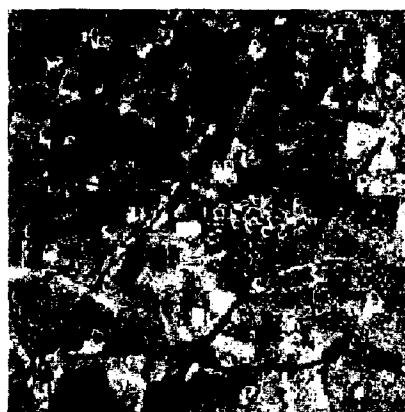
Landsat TM 18-10-93 1:50.000



KVR 1000 19-5-92 1:10.000



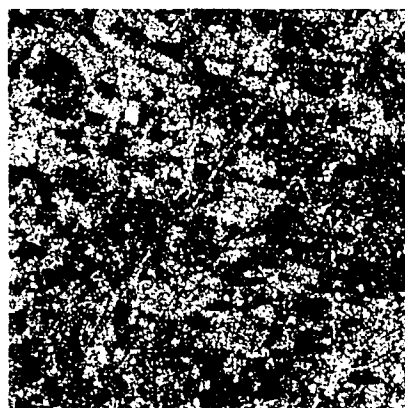
Caesar 3m 22-9-94 1:10.000



SPOT XS 10-6-92 1:50.000



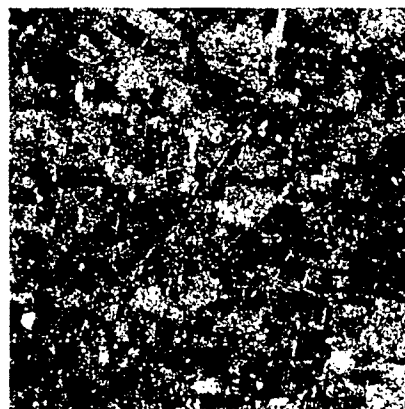
SPOT PAN 13-10-92 1:25.000



ERS 6-8-92 1:100.000



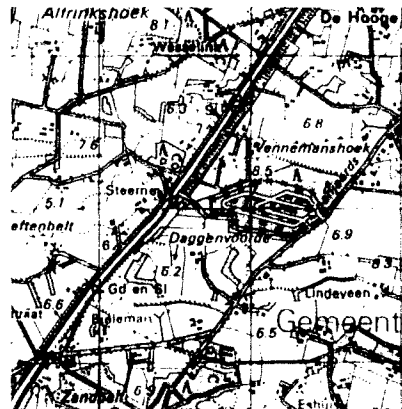
PHARS 27-9-94 1:25.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

**AL240 Tower (toren)****Also: AF010 Chimney/Smokestack (schoorsteen/pijp)****AF030 Cooling Tower (koeltoren)****AF040 Crane (kraan)****AF070 Flare Pipe (fakkel/vlampijp)****AT080 Communication tower (telecommunicatietoren/zendmast)****Definition:**

A relatively tall structure which may be used for observation, support, or storage etc..

**Detection:**

- *Optical:* In low resolution spaceborne images never, in airborne images usually detected like other buildings.
- *TIR:* In airborne images detected like buildings.
- *Microwave:* In airborne images often detected due to double bounce reflections. In spaceborne images only detected when the size of the tower is sufficiently large.

**Recognition:**

- *Optical:* Recognition is difficult. Usually interpreted as a small building. Sometimes on basis of context information and an observable shadow on the ground recognition is possible in higher resolution images.
- *TIR:* Difficult.
- *Microwave:* Usually not possible.

**Attributes:**

**HGT** (height above surface level): using stereographic techniques in the optical region or interferometric techniques in the microwave region with sufficiently high resolution. Sometimes possible using an observable shadow.

**Examples:**

204480, 483563  
210012, 480370  
211485, 480370  
215842, 483213  
218750, 479350



Landsat TM 18-10-93 1:50.000



KVR 1000 19 5 92 1:10.000



Caesar 3m 22 9 94 1:10.000



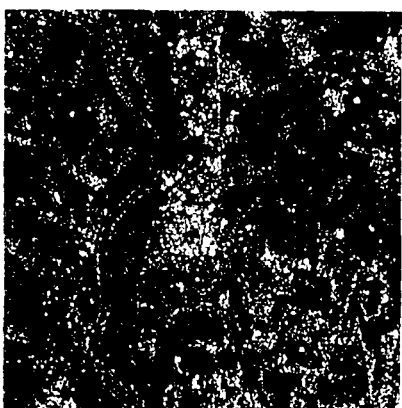
SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



Caesar 1.5m 22 9 94 1:5.000



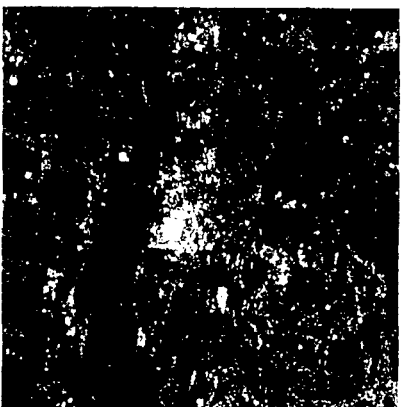
ERS 6-8-92 1:100.000



PHARS 27 9 94 1:25.000



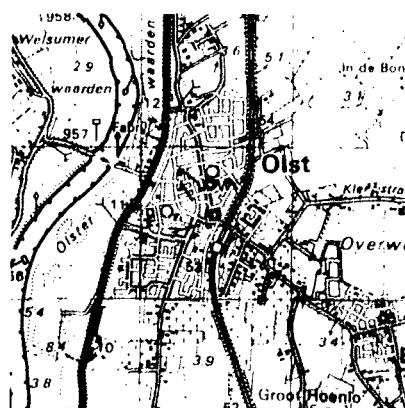
TIR 9/10-94 1:10.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

## **AM080 Water Tower (Watertoren)**

### **Definition:**

An elevated container and its supporting structure used to hold water.

### **Detection and recognition:**

See AL240. The container may give a detectable reflection in higher resolution microwave images.

### **Attributes**

**CAP** (capacity): -

**HGT** (height above surface level): using stereographic techniques in the optical region or interferometric techniques in the microwave region when the resolution is sufficiently high. Sometimes possible using an observable shadow.

### **Examples:**

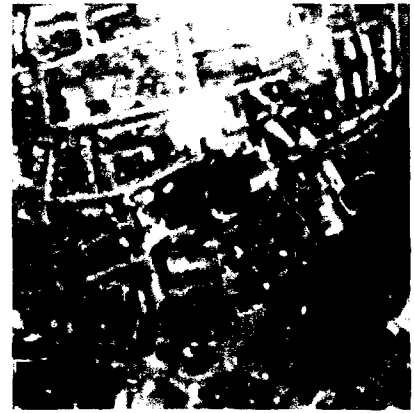
204448, 483765



Landsat TM 18-10-93 1:50.000



KVR 1000 19 5 92 1:10.000



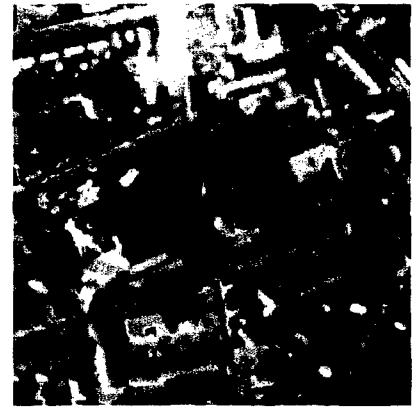
Caesar 3m 22 9 94 1:10.000



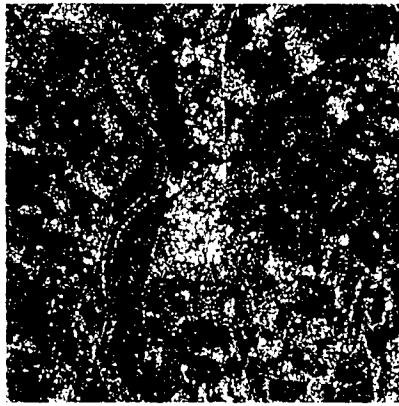
SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



Caesar 1.5m 22 9 94 1:5.000



ERS 6-8-92 1:100.000



PHARS 27 9 94 1:25.000



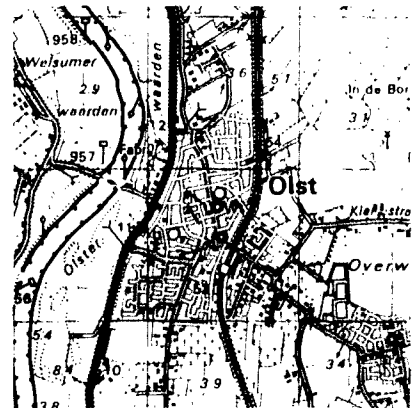
TIR 9/10-94 1:10.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

## **AN010 Railroad (Spoorweg)**

### **Definition:**

A rail or set of parallel rails on which a train or tram runs.

### **Detection:**

Detection is possible as long as the resolution is in the order of or smaller than the width of the railroad. Therefore not well possible for low resolution spaceborne systems like ERS, JERS, XS and TM.

- *Optical*: Due to its line structure and its different spectral signature from the surroundings.
- *TIR*: In day-time possible due to solar heating.
- *Microwave*: By means of line texture and reflections from metal structures. Only possible for airborne systems.

### **Recognition:**

Most important criterion for recognition is its straight linear structure.

- *Optical*: Since the spectral signature is close to that of roads, confusion can exist. Only with high resolution data (< 1.5 m) objects typically belonging to the railroad objects like pylons can be observed.
- *TIR*: Confusion with roads is possible.
- *Microwave*: Confusion with roads can occur, although often reflection from the pylons can prevent confusion.

### **Attributes:**

**LTN** (track/lane number): possible when the resolution is sufficiently high.

**RRA** (rail road power source): sometimes possible when for example wires are detected.

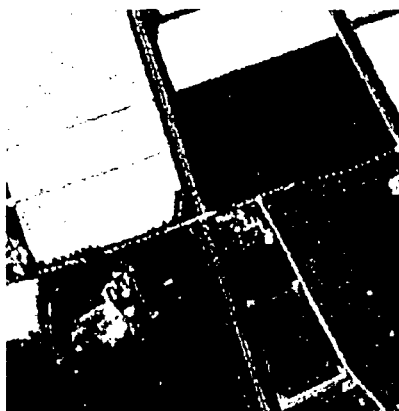
**RRC** (railroad categories): sometimes possible using context information.

### **Examples:**

204732, 484437



Landsat TM 18-10-93 1:50.000



KVR 1000 19-5-92 1:10.000



Caesar 3m 22-9-94 1:10.000



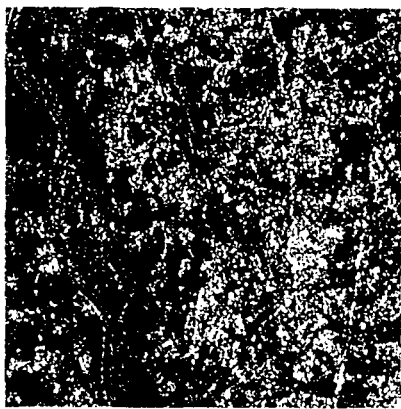
SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



Caesar 1.5m 22-9-94 1:5.000



ERS 6-8-92 1:100.000



PHARS 27-9-94 1:25.000



TIR 9/10-94 1:10.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

## **AP020 Interchange (Kruising)**

### **Definition:**

A connection designed to provide traffic access from one road to another.

### **Detection:**

Only possible when both roads are detected. See further AP030.

### **Recognition:**

See AP030

### **Attributes:**

LC1 (military load class; one-way/wheeled): -

LC2 (military load class; two-way/wheeled): -

LC3 (military load class; one-way/tracked): -

LC4 (military load class; two-way/tracked): -

### **Examples:**

210800, 481892

214675, 486860

210907, 482775



Landsat TM 18-10-93 1:50.000



KVR 1000 19 5 92 1:10.000



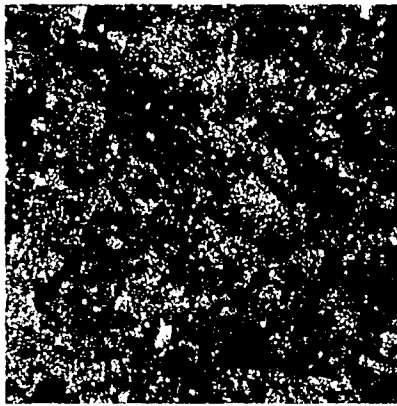
Caesar 3m 22 9 94 1:10.000



SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



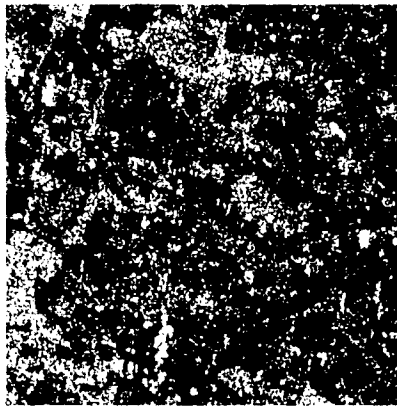
ERS 6-8-92 1:100.000



PHARS 27 9 94 1:25.000



TIR 9/10-94 1:10.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

## AP030 Road (weg/straat)

### Definition:

An open way maintained for vehicular use.

### Detection:

Detection is possible when the resolution is in the order of or smaller than the width of the road.

- *Optical*: Due to the different spectral signature from the surroundings roads are detected depending on the resolution. Detection is not possible for the smaller roads in XS and TM images.
- *TIR*: In day-time and depending on the heat capacity of the upper layer (concrete, asphalt, sand) roads can be detected due to the difference in temperature between the surroundings (vegetation) and the road.
- *Microwave*: Roads usually have smooth surfaces which are dark in SAR images and are therefore detected depending on the resolution. In ERS and JERS images only the main roads are detected.

### Recognition:

Recognition by means of its linear structure.

- *Optical*: Usually no problems. Sometimes roads are obscured by adjacent trees.
- *TIR*: Usually not a problem when detected.
- *Microwave*: Confusion with canals can be a problem.

### Attributes:

- LC1 (military load class; one-way/wheeled): -
- LC2 (military load class; two-way/wheeled): -
- LC3 (military load class; one-way/tracked): -
- LC4 (military load class; two-way/tracked): -
- OHC (overhead clearance category): -
- RST (road surface type): sometimes possible using spectral information in the optical region.
- SGC (gradient/slope): by using available elevation data.

### Examples:

198545, 486454  
210830, 481378  
200335, 484893



Landsat TM 18-10-93 1:50.000



KVR 1000 19-5-92 1:10.000



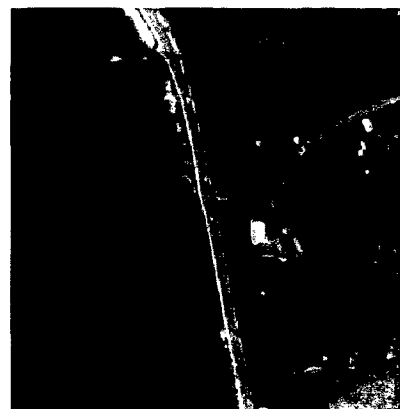
Caesar 3m 22-9-94 1:10.000



SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



Caesar 1.5m 22-9-94 1:5.000



ERS 6-8-92 1:100.000



PHARS 27-9-94 1:25.000



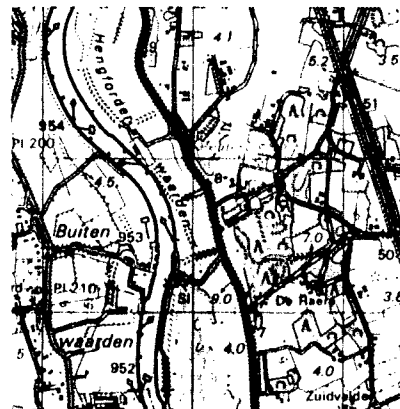
TIR 9/10-94 1:10.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

**AQ040 Bridge/Overpass** (brug/viaduct)**Definition:**

A man-made structure spanning and providing passage over a body of water, depression or other obstacles.

**Detection:**

Possible when all items (roads, canals etc.) characteristic for the passage are detected. In the microwave a strong corner reflection due to the bridge is sometimes observed.

**Recognition:**

Confusion with interchanges can occur. Context information can be a tool to remove the confusion. A strong reflection in the microwave can facilitate the recognition.

**Attributes:**

- LC1 (military load class; one-way/wheeled): -
- LC2 (military load class; two-way/wheeled): -
- LC3 (military load class; one-way/tracked): -
- LC4 (military load class; two-way/tracked): -
- NOS (number of spans): -

**Examples:**

210805, 482048  
215340, 485930  
198308, 487449  
214663, 481175



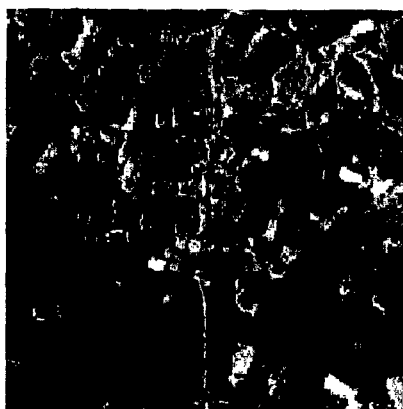
Landsat TM 18-10-93 1:50.000



KVR 1000 19 5 92 1:10.000



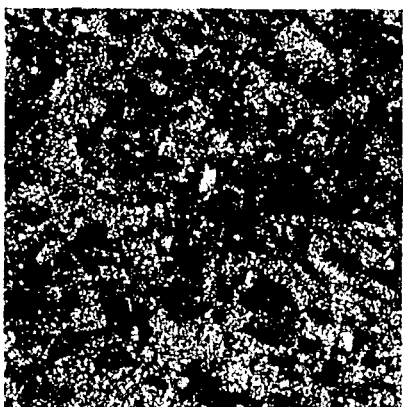
Caesar 3m 22 9 94 1:10.000



SPOT XS 10-6-92 1:50.000



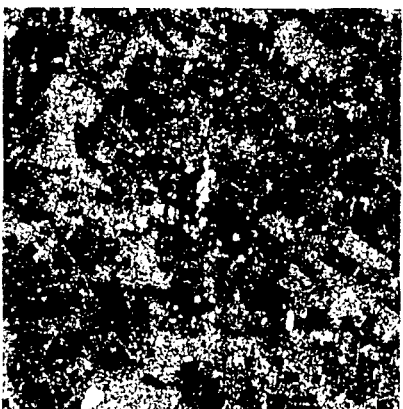
SPOT PAN 13-10-92 1:25.000



ERS 6-8-92 1:100.000



PHARS 27 9 94 1:25.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

**AQ045 Bridge span** (overspanning)**Definition:**

A section of the bridge deck between successive supports such as pillars, piers or abutments.

**Detection:**

Difficult since the pillars are usually beneath the bridge deck. With high resolution radar data sometimes reflections can be seen from the pillars etc.

**Recognition:**

When the pillars etc. are detected the recognition is usually straightforward due to the context.

**Attributes:**

**LC1** (military load class; one-way/wheeled): -

**LC2** (military load class; two-way/wheeled): -

**LC3** (military load class; one-way/tracked): -

**LC4** (military load class; two-way/tracked): -

**EXS** (existence category): this is sometimes possible when the resolution is sufficiently high.

**Examples:**

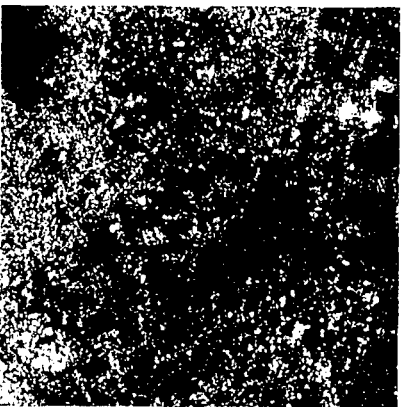
198540, 486226



Landsat TM 18-10-93 1:50.000



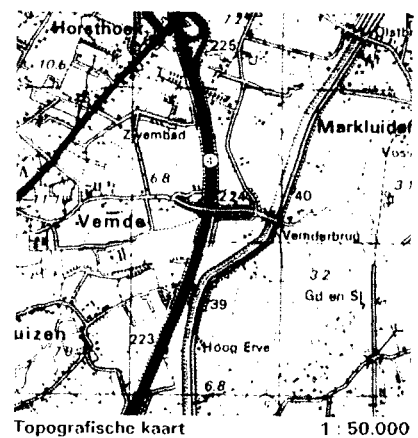
SPOT XS 10-6-92 1:50.000



ERS 6-8-92 1:100.000



JERS 20-9-93 1:100.000



Topografische kaart 1:50.000

## **AQ065 Culvert (Duiker)**

### **Definition:**

A sewer or drain crossing under a road, track, or embankment, without affecting the construction of the crossed feature.

### **Detection:**

Because of the small dimension not possible with low resolution spaceborne data. With airborne data only indirectly detected when both the ditch and the road are detected, but no sign of a bridge is seen.

### **Recognition:**

Indirect when both ditch and road are detected but no sign of a bridge is seen.

### **Remark:**

The potential of the different sensors types (optical, TIR, microwave) depends in this case on the ability of each sensor to detect and identify roads and ditches.

### **Attributes:**

### **Examples:**

210853, 480590

214665, 481035



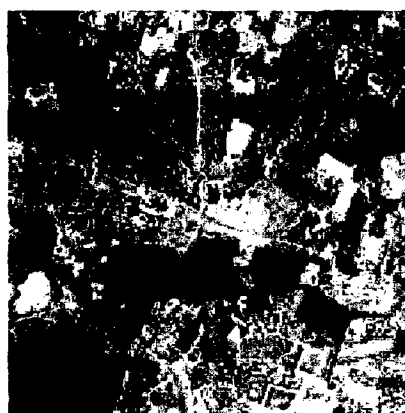
Landsat TM 18-10-93 1:50.000



KVR 1000 19-5-92 1:10.000



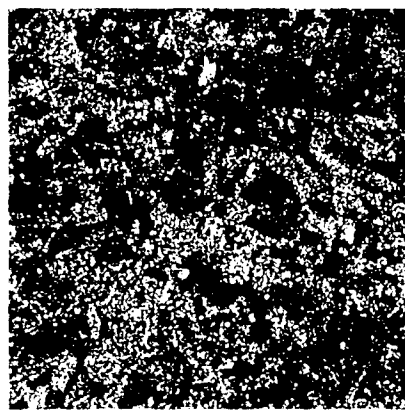
Caesar 3m 22-9-94 1:10.000



SPOT XS 10-6-92 1:50.000



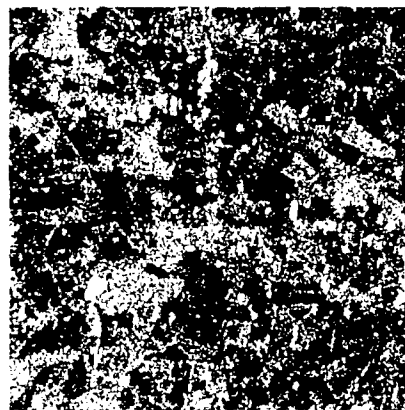
SPOT PAN 13-10-92 1:25.000



ERS 6-8-92 1:100.000



PHARS 27-9-94 1:25.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

## **AQ116 Pumping station** (pompstation)

### **Definition:**

A facility to move solids, liquids or gases by means of pressure or suction.

### **Detection:**

Seen the small dimensions of the facility these objects are not detected in low resolution spaceborne data (e.g., basin of sewage treatment plant).

- *Optical*: By means of the spectral signature of the man-made objects.
- *TIR*: Detected if excess heat is present and in day-time due to solar heating of man-made structures
- *Microwave*: Detected due to high reflections from man-made structures.

### **Recognition:**

- *Optical*: In high resolution images (< 3 m) due to its specific shape.
- *TIR*: Difficult
- *Microwave*: Not well possible.

### **Attributes:**

### **Examples:**

204238, 484890

205293, 485091

AQ116 Pompstation Waterzuiveringsinstallatie Olst (RD: 204238, 484890)

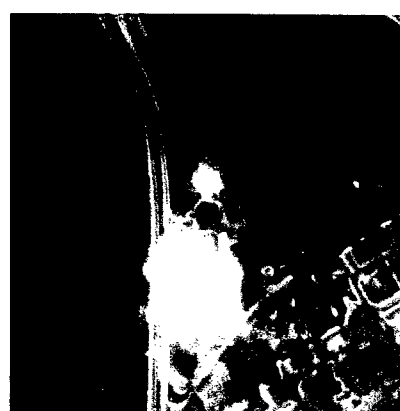
B.33



Landsat TM 18-10-93 1:50.000



KVR 1000 19 5 92 1:10.000



Caesar 3m 22 9 94 1:10.000



SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



Caesar 1.5m 22 9 94 1:5.000



ERS 6-8-92 1:100.000



PHARS 27 9 94 1:25.000



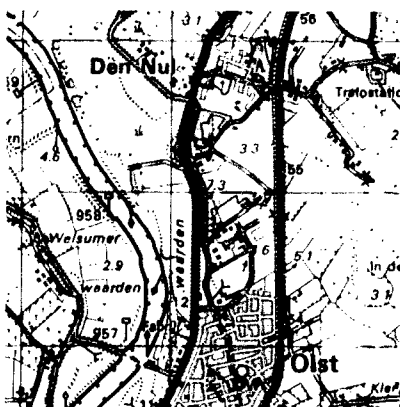
TIR 9/10-94 1:10.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1: 50.000

**AQ118 Sharp curve** (scherpe bocht)**Definition:**

a curve which may cause transportation restrictions.

**Detection:**

depending on the detection of the road showing the curve.

**Recognition:**

depending on the recognition of the road showing the curve.

**Remark:**

The potential of the different sensors types (optical, TIR, microwave) depends in this cases on the ability of each sensor to detect and identify roads.

**Attributes:**

**RAD** (radius of sharp curve): the radius can be determined when the road is detected along the curve.

**Examples:**

207580, 484908

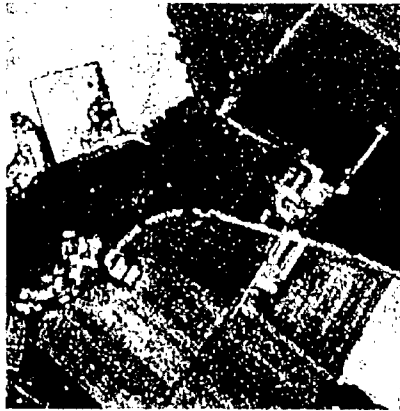
210200, 487058

AQ118 Scherpe bocht Bocht Middelerstraat (RD: 207580, 484908)

B.35



Landsat TM 18-10-93 1:50.000



KVR 1000 19 5 92 1:10.000



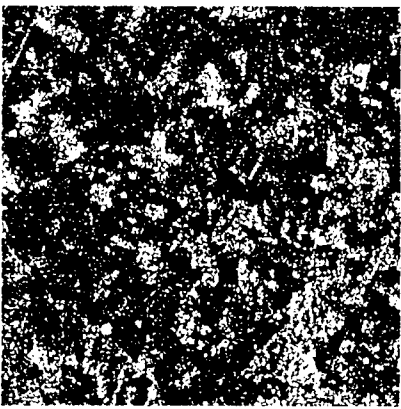
Caesar 3m 22 9 94 1:10.000



SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



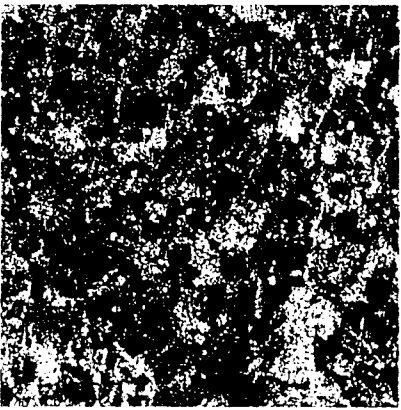
ERS 6-8-92 1:100.000



PHARS 27 9 94 1:25.000



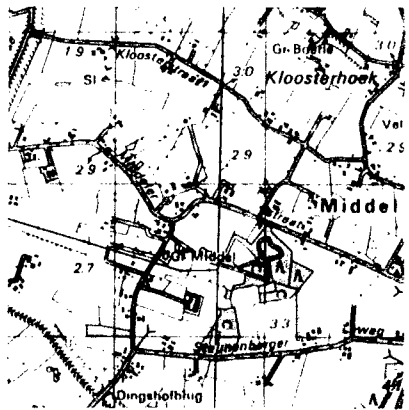
TIR 9/10-94 1:10.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

## AQ125 Station (station)

### Definition:

A stopping place for the transfer of passengers and/or freight.

### Detection:

By means of detection of platforms; therefore only possible with higher resolution imagery ( $< 10\text{m}$ ).

- *Optical*: By means of different spectral signature of the platform.
- *TIR*: Difficult since the heat capacity of platform and railroads do not differ significantly.
- *Microwave*: By means of reflections from man-made structures like buildings and platforms.

**Recognition:** By means of the combined detection of platforms, railroads and man-made buildings or context information (splitting railroads etc.).

- *Optical*: Only with higher resolution systems ( $< 10\text{m}$ )
- *TIR*: Only possible with high resolution ( $< 5\text{ m}$ ) systems.
- *Microwave*: Only possible with high resolution ( $< 5\text{m}$ ) systems

### Attributes:

### Examples:

204503, 483343



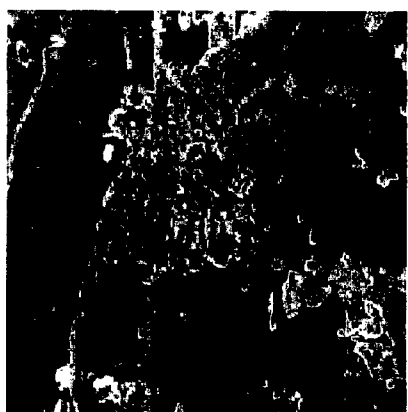
Landsat TM 18-10-93 1:50.000



KVR 1000 19-5-92 1:10.000



Caesar 3m 22-9-94 1:10.000



SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



Caesar 1.5m 22-9-94 1:5.000



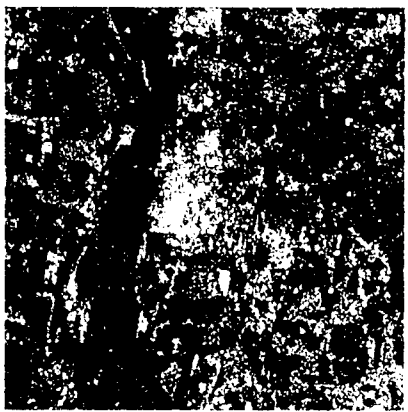
ERS 6-8-92 1:100.000



PHARS 27-9-94 1:25.000



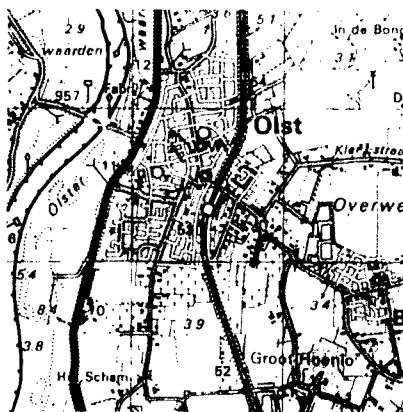
TIR 9/10-94 1:10.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

## AQ135 Vehicle Stopping Area/Rest area (parkeerplaats)

### Definition:

A roadside place usually having facilities for people and/or vehicles.

### Detection:

Depending on the size of the area. Usually not feasible for the lower resolution (> 20 m ) spaceborne sensors.

- *Optical*: By means of its spectral signature differing from vegetation
- *TIR*: By means of the different heat capacity of the surface.
- *Microwave*: Detected by means of its dark appearance because of the usually smooth surface.

### Recognition:

By means of its detection and the detection of nearby roads.

- *Optical*: Possible for systems with resolutions smaller than about 5 m.
- *TIR*: Possible when there is a temperature difference, e.g. to solar heating compared to the surroundings.
- *Microwave*: Difficult since confusion exists with smooth bare soil fields.

### Attributes:

SWL (single wheel bearing load): -

### Examples:

208000, 479065

203725, 480280

AQ135 Parkeerplaats

Parkeerplaats golfterrein Diepenveen (RD: 208000, 479065)

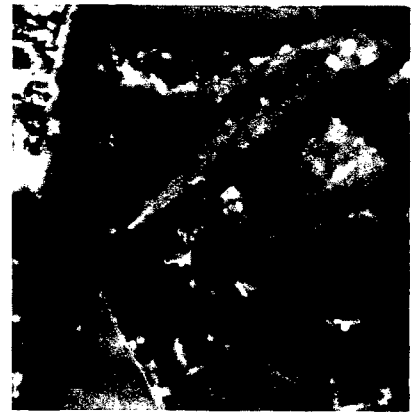
B.39



Landsat TM 18-10-93 1:50.000



KVR 1000 19-5-92 1:10.000



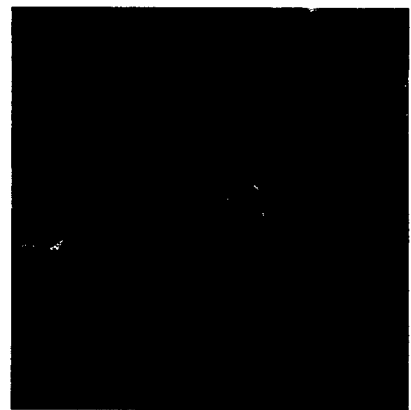
Caesar 3m 22-9-94 1:10.000



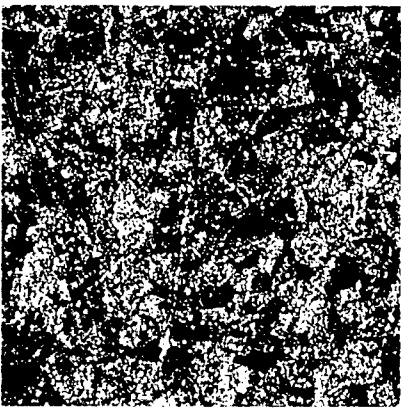
SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



Caesar 1.5m 22-9-94 1:5.000



ERS 6-8-92 1:100.000



PHARS 27-9-94 1:25.000



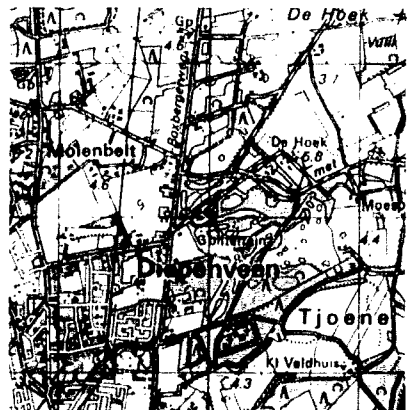
TIR 9/10-94 1:10.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

## AT030 Power transmission line (hoogspanningsleiding)

### Definition:

A system of above ground wires including their supports, which transmits electricity over a distance.

### Detection:

Directly due to reflections from the wires or indirectly due to reflections from the pylons.

- *Optical*: Not well possible. Only in the high resolution images (< 3 m) the pylon are detected.
- *TIR*: Not well possible
- *Microwave*: When the flying direction is parallel to the wires sometimes strong reflections are seen. In the higher resolution imagery (resolution < 5 m) pylons are detected due to double bounce reflections.

### Recognition:

By means of the linear appearance of the detected pylons.

- *Optical*: Not well possible. Only in the higher resolution images hints of wires can be seen. These together with the detected pylons enable detection.
- *TIR*: Not well possible.
- *Microwave*: Possible with both ERS and JERS when the wires are aligned parallel to the orbit direction. For the higher resolution images (< 5m) detected pylons in a row enable detection.

### Attributes:

### Examples:

201180, 484055

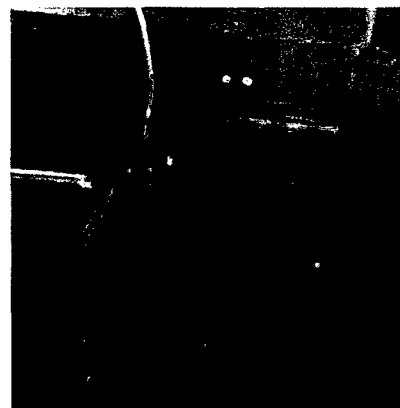
207675, 484086



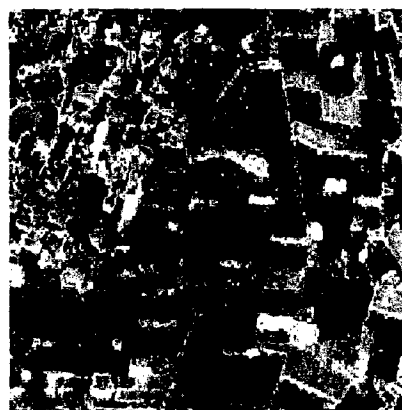
Landsat TM 18-10-93 1:50.000



KVR 1000 19-5-92 1:10.000



Caesar 3m 22-9-94 1:10.000



SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



ERS 6-8-92 1:100.000



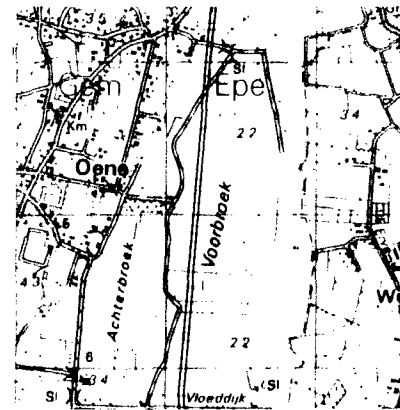
PHARS 27-9-94 1:25.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

**AT040 Power Transmission Pylon** (hoogspanningsmast)**Definition:**

A pylon or pole used to support a power transmission line.

**Detection:**

By means of the reflection from the pylons.

- *Optical*: Only in the high resolution images (< 3 m) pylons are detected.
- *TIR*: Not well possible
- *Microwave*: In the higher resolution imagery (resolution < 5 m) pylons are detected due to double bounce reflections.

**Recognition:**

By means of an apparent array of detected pylons. See detection.

**Attributes:****Examples:**

201178, 483880

201200, 484228

201288, 480760

# AT040 Hoogspanningsmast Welsumerveld (RD: 201260, 480780)

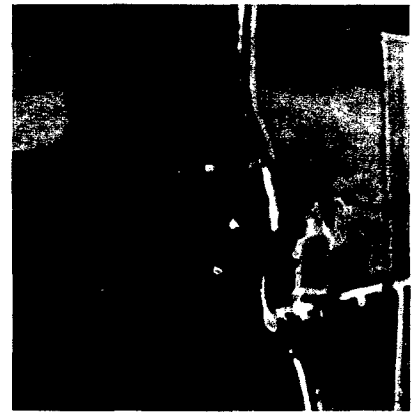
B.43



Landsat TM 18-10-93 1:50.000



KVR 1000 19-5-92 1:10.000



Caesar 3m 22-9-94 1:10.000



SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



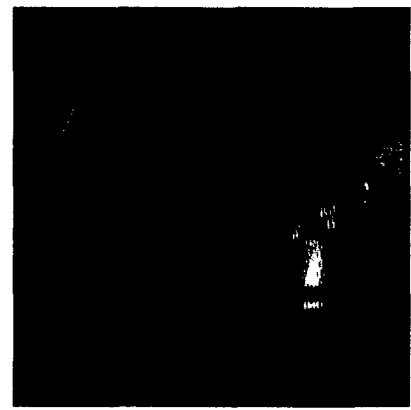
Caesar 1.5m 22-9-94 1:5.000



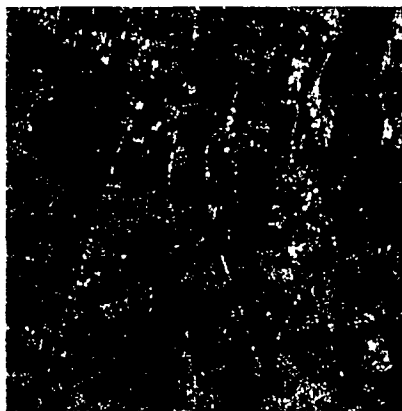
ERS 6-8-92 1:100.000



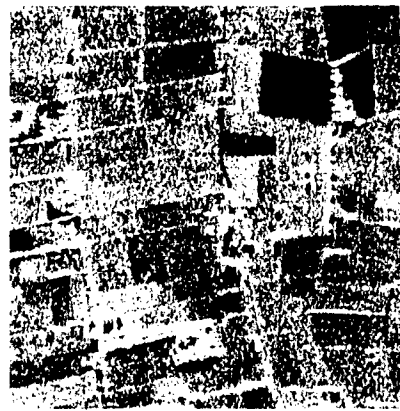
PHARS 27-9-94 1:25.000



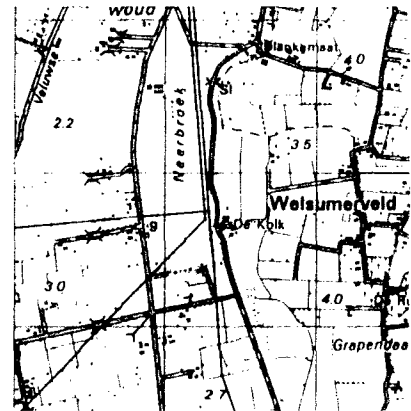
TIR 9/10-94 1:10.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

**BB140 Jetty (krib/havendam)****Definition:**

A man-made barrier built out into, or in the water primarily to restrain or direct currents and waves.

**Detection:**

Depending on the size. In rivers only possible for a resolution better than 10 m.

- *Optical*: By means of the different spectral signature of water and the jetty.
- *TIR*: Possible when the temperature of the water and the jetty differ.
- *Microwave*: Possible because of the contrast in backscatter level for the water and the jetty.

**Recognition:**

By means of its typical shape at the border of the river or coast. For all three wavelength regions: a somewhat better resolution (5 m for the river) than required for the detection suffices.

**Attributes:****Examples:**

203940, 484350

204395, 478215



Landsat TM 18-10-93 1:50.000



KVR 1000 19-5-92 1:10.000



Caesar 3m 22-9-94 1:10.000



SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



Caesar 1.5m 22-9-94 1:5.000



ERS 6-8-92 1:100.000



PHARS 27-9-94 1:25.000



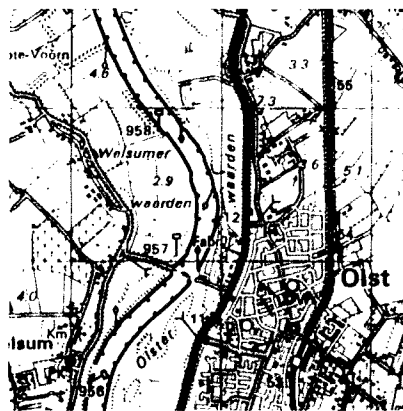
TIR 9/10-94 1:10.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

**BG010 Current Flow** (vaargeul)**Definition:**

A designation or symbol on a map or chart indicating the flow direction of a current.

**Detection and recognition:**

Possible with along track interferometry by directly measuring the velocity of the water surface. Sometimes indirectly possible due to the shape of meanders in rivers. Sometimes possible in the microwave region with airborne SAR (resolution  $< 5$  m is needed) when the water surface is roughened due to the current. In such a case the image of the current is displaced due to its motion indicating the direction.

**Attributes:****Examples:**

No images available.

**BH020 Canal** (kanaal/vaart)**Definition:**

A man-made or improved natural waterway used for transportation.

**Detection:**

Detection is possible when the resolution is in the order or smaller than the width of the canal.

- *Optical*: Possible by means of the different spectral signature of the water and the surroundings.
- *TIR*: Necessary condition for detection is an observable difference in temperature of the canal-water and the surroundings.  
*Microwave*: Since the canal water is usually a smooth surface (except for strong winds) canals appear dark compared to their surroundings in SAR images.

**Recognition:**

By means of its straight linear structure.

- *Optical*: Usually not a problem when detected. Especially near-infrared channels show the different spectral signature of the water.
- *TIR*: Usually not a problem when detected.
- *Microwave*: Confusion with roads can occur since these are also linear structures which appear dark in the scene.

**Attributes:**

**WDA** (water depth average): -

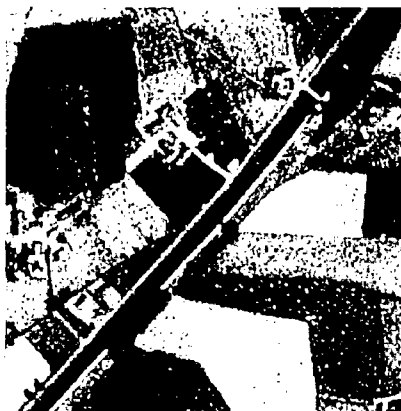
**WID** (width): can be determined when the resolution is sufficiently high.

**Examples:**

213303, 478887



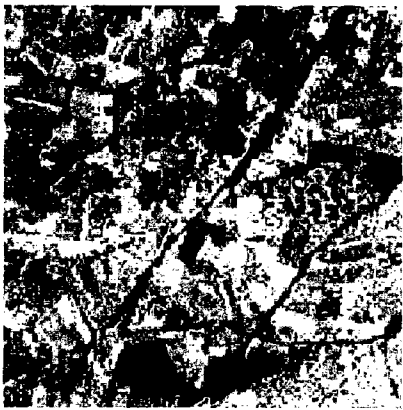
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KVR 1000 19-5-92 1:10.000



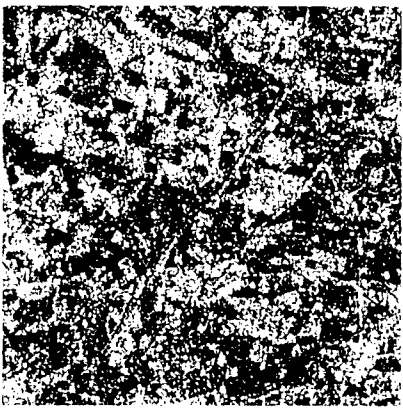
Caesar 3m 22-9-94 1:10.000



SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



ERS 6-8-92 1:100.000



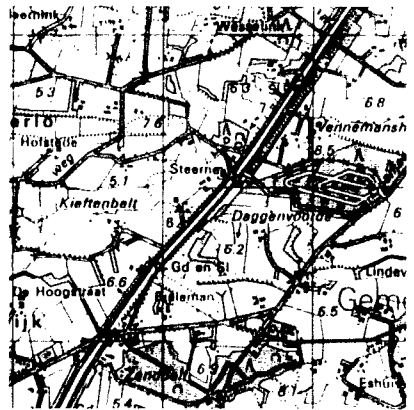
PHARS 27-9-94 1:25.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

**BH030 Ditch** (sloot/greppel)**Definition:**

A channel constructed for the purpose of irrigation or drainage.

**Detection:**

Because of the smaller width detection is only possible for the higher resolution images ( $< 5$  m). For other remarks see BH020.

**Recognition:**

For all three wavelength regions by means of its linear structure like for channels. For recognition the resolution should be in the order of the width ( $< 3$  m). For intermediate resolutions (3 - 10 m) confusion with field boundaries etc. can exist.

**Attributes:**

**WID** (width): can be determined when the resolution is sufficiently high.

**Examples:**

214020, 479628



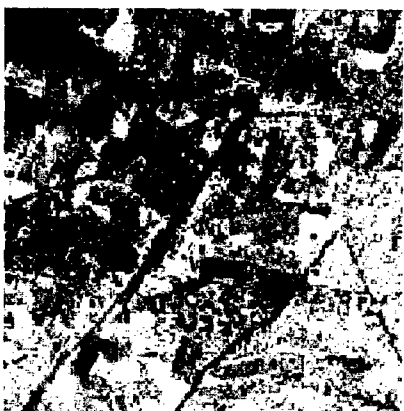
Landsat TM 18-10-93 1:50.000



KVR 1000 19-5-92 1:10.000



Caesar 3m 22-9-94 1:10.000



SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



ERS 6-8-92 1:100.000



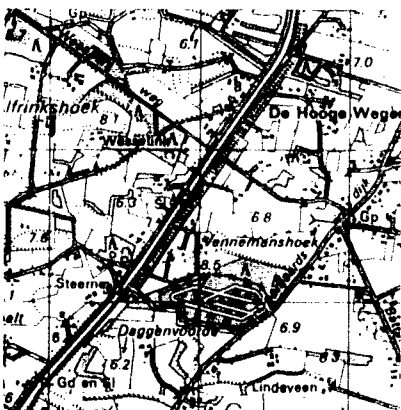
PHARS 27-9-94 1:25.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

**BH080 Lake/pond** (meer/plas/vijver)**Definition:**

A body of water surrounded by land.

**Detection:**

Usually not a problem as long as the object is larger than the resolution.

- *Optical*: By means of the spectral signature of water compared to land. Especially near-infrared channels are useful.
- *TIR*: Requirement is an observable difference in temperature for the water and the land.
- *Microwave*: Since the water is usually smooth it appears much darker than the surroundings. However, for larger lakes wind easily produces small waves resulting in a brighter appearance of the water. In these cases the real extent of the lake is sometimes difficult to determine.

**Recognition:**

For all three wavelength bands usually not a problem because of the particular shape in image. Determination of the shape however requires that the extent of the lake is significantly larger than the resolution.

**Attributes:**

SCC (spring/well characteristic category): determination is only possible using context information.

**Examples:**

215557, 478883

208763, 478863

203806, 483103



Landsat TM 18-10-93 1:50.000



KVR 1000 19 5 92 1:10.000



Caesar 3m 22 9 94 1:10.000



SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



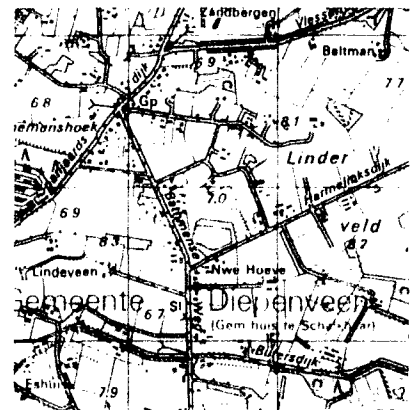
ERS 6-8-92 1:100.000



PHARS 27 9 94 1:25.000



JERS 20-9-93 1:100.000



Topografische kaart 1:50.000

**BH090 Land subject to inundation** (uiterwaarden/overstromingsgebied)**Definition:**

An area periodically covered by flood water, excluding tidal waters.

**Detection:**

Difficult to detect directly.

- *Optical:* Moistly soil and accompanying vegetation in such areas may be detectable using the near-infrared bands.
- *TIR:* Since water has a high water capacity moistly soil will change less in temperature. Collecting data at appropriate times during the day can therefore help the detection of these areas.
- *Microwave:* Low vegetation and smooth soil in such an area give a rather low backscatter level.

**Recognition:**

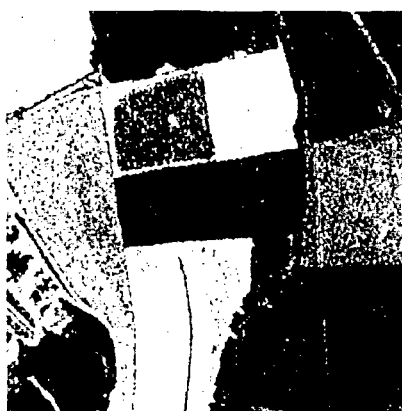
For all three bands this is sometimes possible using context information, e.g., from apparent difference in land use near a river.

**Attributes:****Examples:**

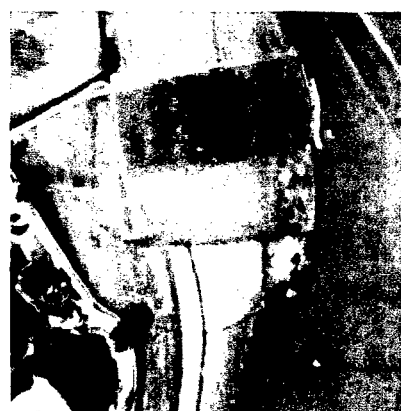
203498, 484475



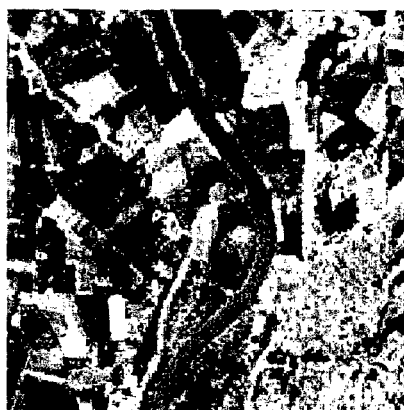
Landsat TM 18-10-93 1:50.000



KVR 1000 19 5 92 1:10.000



Caesar 3m 22 9 94 1:10.000



SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



Caesar 1.5m 22 9 94 1:5.000



ERS 6-8-92 1:100.000



PHARS 27 9 94 1:25.000



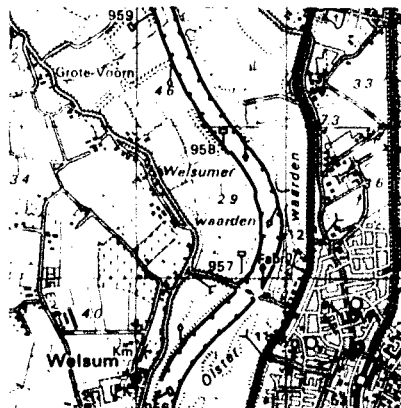
TIR 9/10-94 1:10.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

**BH100 Moat** (gracht)**Definition:**

A trench usually filled with water, that surrounds a body of land

**Detection:**

Detection is possible when the resolution is in the order of or smaller than the width of the canal.

- *Optical*: Possible by means of the different spectral signature of the water and the surroundings. Especially near-infrared channels show the different spectral signature of the water.
- *TIR*: Necessary condition for detection is an observable difference in temperature of the canal-water and the surroundings.
- *Microwave*: Since the canal water is usually a smooth surface (except in case of strong winds) the canals appear darker in SAR images than their surroundings.

**Recognition:**

For all three wavelength regions by means of its linear structure. To avoid confusion with channels context information is important. Resolution should be higher than the width of the body to reveal the shape of the moat.

**Attributes:**

**WID** (width): can be determined when the resolution is sufficiently high.

**Examples:**

206675, 478528



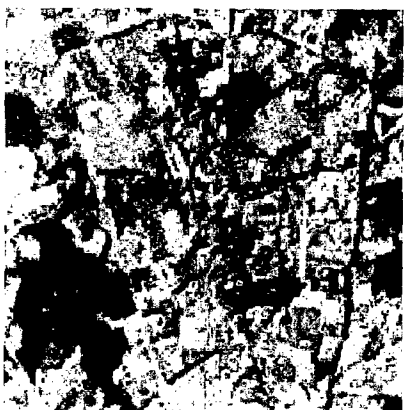
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KVR 1000 19-5-92 1:10.000



Caesar 3m 22-9-94 1:10.000



SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



ERS 6-8-92 1:100.000



PHARS 27-9-94 1:25.000



TIR 9/10-94 1:10.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

**BH115 Underground water** (grondwater)**Definition:**

Water situated underground but reachable by wells.

**Detection and recognition:**

In principle only indirectly possible by remote sensing sensors. Wet soil may be detected and using geophysical models some information about this feature may be obtained.

**Attributes:****Examples:**

No images available.

**BH140 River/stream** (rivier/stroom/beek)**Definition:**

A natural flowing watercourse

**Detection:**

Detection is possible when the resolution is in the order of or smaller than the width of the canal.

- *Optical*: Possible by means of the different spectral signature of the water and the surroundings. Especially near-infrared channels show the different spectral signature of the water.
- *TIR*: necessary condition for detection is difference in temperature of the canal-water and the surroundings.
- *Microwave*: Since the water is usually a smooth surface (except during strong winds) rivers usually appear darker in SAR images than their surroundings.

**Recognition:**

For all three wavelength regions recognition is usually not a problem due to its apparent specific linear structure (e. g. meanders).

**Attributes:**

**DOF** (direction of flow): is possible with along track microwave interferometry.

**WID** (width): can be determined when the resolution is sufficiently high

**WVA** (water velocity average): is possible with along track microwave interferometry.

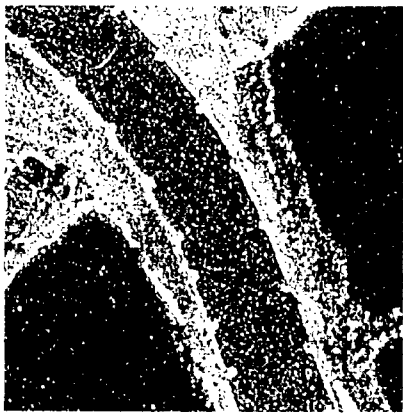
**Examples:**

203138, 485815

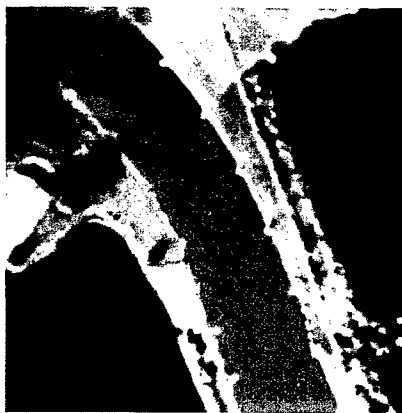
211786, 480106



Landsat TM 18-10-93 1:50.000



KVR 1000 19 5 92 1:10.000



Caesar 3m 22 9 94 1:10.000



SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



ERS 6-8-92 1:100.000



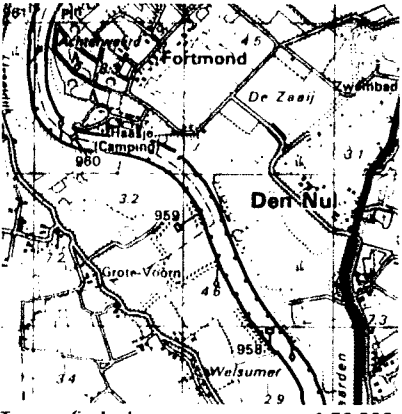
PHARS 27 9 94 1:25.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

**BH501 Waterway (vaargeul)****Definition:**

Deeper part of a stream or channel where ships can sail.

**Detection and recognition:**

Difficult to detect or identify directly. Depending on the context information sometimes the most likely waterway can be detected. Sandbanks in a riverbed are usually well be observed in the optical region due to their spectral signature being different from the water.

**Attributes:****Examples:**

203758, 483930



Landsat TM 18-10-93 1:50.000



KVR 1000 19-5-92 1:10.000



Caesar 3m 22-9-94 1:10.000



SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



Caesar 1.5m 22-9-94 1:5.000



ERS 6-8-92 1:100.000



PHARS 27-9-94 1:25.000



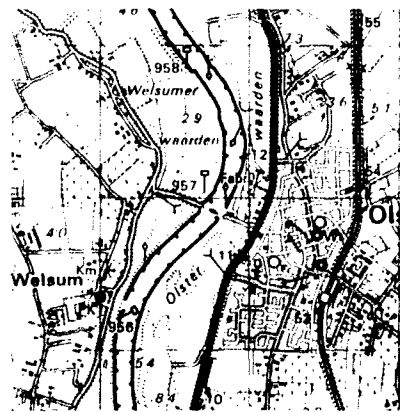
TIR 9/10-94 1:10.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

**BI020 Dam/Weir** (stuwdam/stuw)**Also: BI040 Sluice gate** (sluisdeur)**Definition:**

A permanent barrier across a watercourse used to impound water or to control its flow. A gate used to regulate the flow of water

**Detection:**

Depends on the size of the structure. Therefore not possible with low resolution satellite imagery.

- *Optical:* These structures may be relatively small hindering the detection in the optical. The spectral signature of the object is however different from the water so that the object is easily detected when its size is large enough.
- *TIR:* Difference in temperature between the object and its surroundings enables detection when the size is large enough.
- *Microwave:* When the orientation of the object towards the radar is appropriate, detection is possible by means of double reflections between the object and the water.

**Recognition:**

For all three wavelengths regions: when detected, recognition is quite straightforward. Confusion with a bridge can occur, however.

**Attributes:**

**EXS** (existence category): this is sometimes possible when the resolution is sufficiently high.

**MCC** (material composition category): -

**Examples:**

201117, 485955



Landsat TM 18-10-93 1:50.000



KVR 1000 19-5-92 1:10.000



Caesar 3m 22-9-94 1:10.000



SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



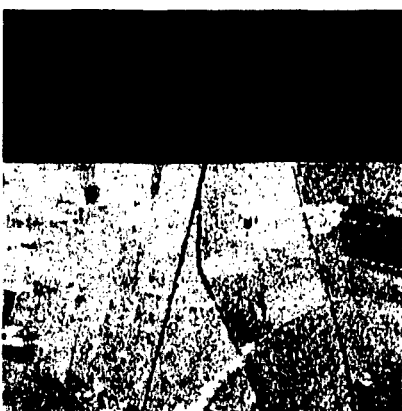
ERS 6-8-92 1:100.000



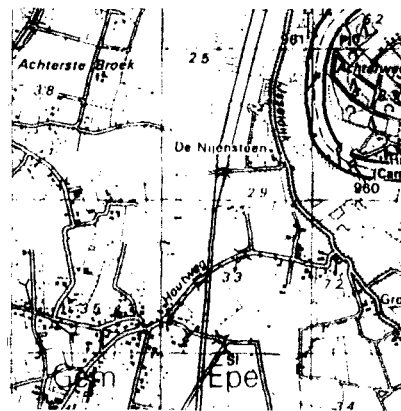
PHARS 27-9-94 1:25.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

**BI030 Lock (schutsluis)****Definition:**

An enclosure with pair or series of gates used for raising or lowering vessels as they pass from one water level to another.

**Detection and recognition:**

Since the object is usually a complex consisting of several gate-like structures the remarks for BI020 apply. Since the complex is larger and also the waterway/flow is often changed near the lock detection and recognition is significantly easier.

**Attributes:****Examples:**

No images available.

**CA030 Spot elevation** (hoogtepunt)

**Also:** CA010 Contour line (hoogtelijn)

**Definition:**

A designated location with an elevation value relative to a vertical datum.

**Detection and Recognition:**

Directly with stereo techniques (optical) or with interferometric techniques (microwave), both requiring two separate images. The resolution in vertical direction depends on the ground resolution and with the low resolution satellite sensors detectable relief is only feasible for mountainous areas. Indirectly, differences in relief can sometimes be retrieved from differences in vegetation which may be observable by the sensors.

**Attributes:**

**ZV1** (lowest Z-value; elevation above a given datum to the lowest portion of the feature): by using stereographic techniques in the optical or interferometric techniques in the microwave region.

**Examples:**

208568, 478845



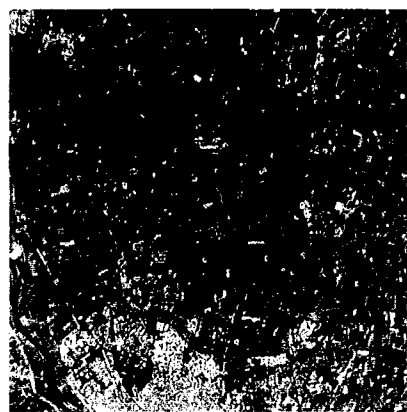
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KVR 1000 19-5-92 1:10.000



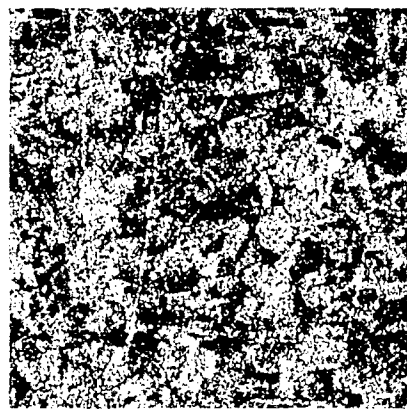
Caesar 3m 22-9-94 1:10.000



SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



ERS 6-8-92 1:100.000



PHARS 27-9-94 1:25.000



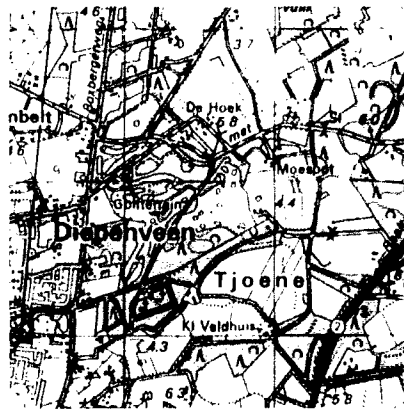
TIR 9/10-94 1:10.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

**DA010 Ground surface element** (bodemgesteldheid)**Definition:**

The characteristics of the soil.

**Detection and recognition:**

When the soil can be observed directly (bare soil, see feature DA020) optical and TIR sensors may provide useful information about the soil characteristics. In the optical region especially the near-infrared bands can give information about the soil composites and moisture. TIR can give information about soil moisture, since dry soil has a bigger heat capacity than wet soil, so that the first is more sensitive to temperature changes. Microwave sensors can give information about soil roughness.

**Attributes:**

**STP** (soil type): some information may be obtained using spectral information in the optical region.

**SWC** (soil wetness condition): can sometimes be determined by comparing optical or microwave images of different dates.

**Examples:**

No images available.

**DA020 Barren ground** (kale grond)**Definition:**

Land surface void of vegetation or other specific surface material.

**Detection:**

The resolution should be smaller than the barren ground field to be detected.

- *Optical:* The spectral signature of bare soil is quite different from that of vegetation. The near-infrared band is especially suited for detection.
- *TIR:* possible depending on circumstances. Bare soil is usually more subject to temperature changes than vegetation, so that for example extremely warm surfaces may indicate bare soil.
- *Microwave:* Sandy soil or cultivated soil with smooth surfaces appear quite dark in radar images.

**Recognition:**

For the optical and TIR: when detected recognition is usually not a problem. Only in build-up areas confusion may occur with bare soil and pavement.

In the microwave confusion with water surfaces can occur.

**Attributes:****Examples:**

209108, 479815

186000, 490000



Landsat TM 18-10-93 1:50.000



KVR 1000 19 5 92 1:10.000



Caesar 3m 22 9 94 1:10.000



SPOT XS 10-6-92 1:50.000



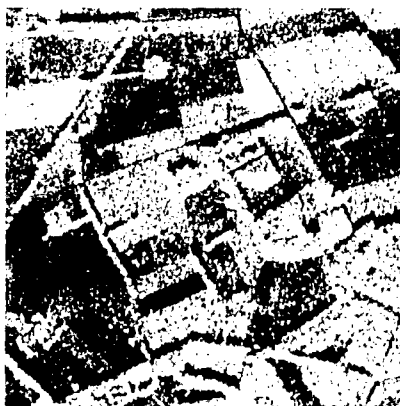
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Caesar 1.5m 22 9 94 1:5.000



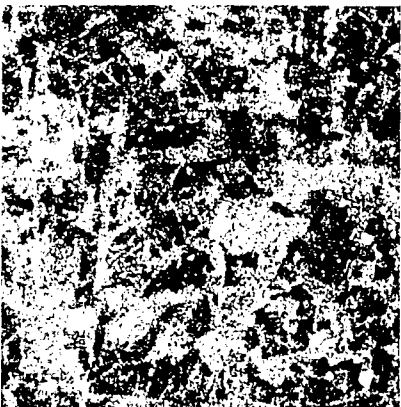
ERS 6-8-92 1:100.000



PHARS 27 9 94 1:25.000



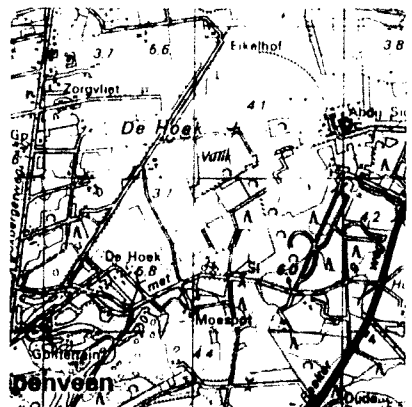
TIR 9/10-94 1:10.000



JERS 20-9-93 1:100.000



PHARUS 2 6 97 1:25.000



Topografische kaart 1:50.000

**DB070 Cut** (doorsnijding)**Definition:**

An excavation of the Earth's surface to provide passage for a road, railroad, canal, etc..

**Detection or recognition:** difficult.

**Attributes:****Examples:**

No images available.

**DB080 Depression** (depressie/inzinking)**Definition:**

A low area surrounded by higher ground.

**Detection/recognition:**

see CA010/CA030.

**Attributes:**

**ZV1** (lowest Z-value; elevation above a given datum to the lowest portion of the feature): by using stereographic techniques in the optical or interferometric techniques in the microwave region.

**Examples:**

208763, 478863

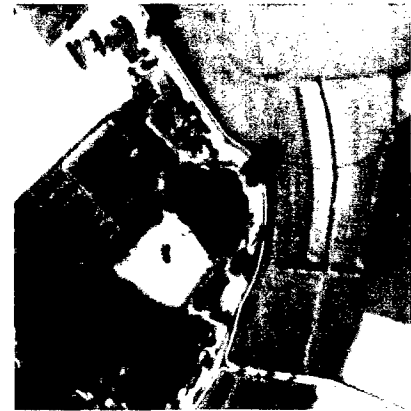
203328, 484268



Landsat TM 18-10-93 1:50.000



KVR 1000 19-5-92 1:10.000



Caesar 3m 22-9-94 1:10.000



SPOT XS 10-6-92 1:50.000



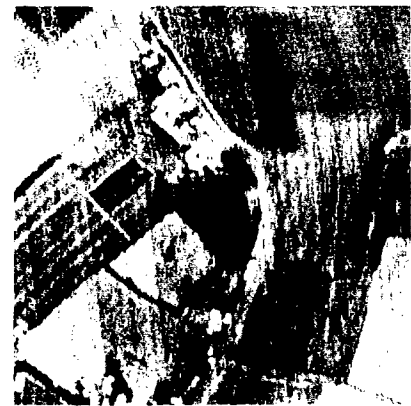
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ERS 6-8-92 1:100.000



PHARS 27-9-94 1:25.000



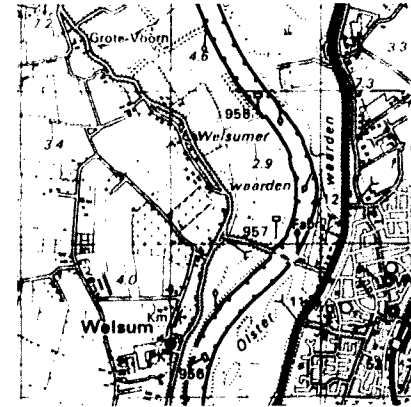
TIR 9/10-94 1:10.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

**DB090 Embankment/Fill (dijk/dam)****Definition:**

A raised long mound of earth or other material

**Detection:**

Difficult to detect directly. Sometimes by means of an observable line of shadow.

Indirectly due to different types of vegetation.

- *Optical*: When the sun is low in the sky a shadow may be seen. Indirectly by observing a different spectral signature from a different type of vegetation on the dike.
- *TIR*: Due to differences in soil water balance between the dike and the surroundings observable differences in temperature can exist.
- *Microwave*: When the slope of the dike is steep and the dike is more or less in azimuth direction a shadow is observed.

**Recognition:**

For all three wavelength bands by means of its linear structure and taking into the local geography into account. Confusion with roads may occur for the microwave band.

**Attributes:**

**HGT** (height above surface level): by using stereographic techniques in the optical or interferometric techniques in the microwave band with sufficient resolution.

**MCC** (material composition category): -

**Examples:**

203515, 484018

203927, 480630

204373, 478298

204868, 478548



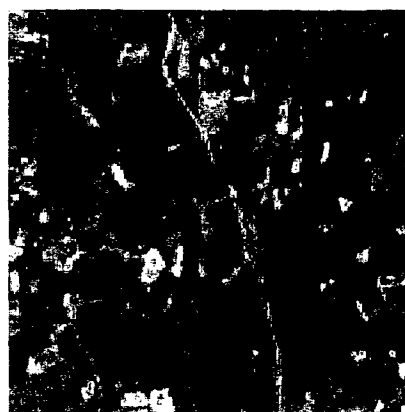
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KVR 1000 19-5-92 1:10.000



Caesar 3m 22-9-94 1:10.000



SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



Caesar 1.5m 22-9-94 1:5.000



ERS 6-8-92 1:100.000



PHARS 27-9-94 1:25.000



TIR 9/10-94 1:10.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

**DB501 Upper part of a cliff** (bovenrand van steile wand)

**Also: DB010 Cliff** (steile wand/klif/overhelling)

**Definition:**

A steep, vertical, or overhanging face of rock or earth.

**Detection and recognition:**

By means of an observable shadow in the image. Detection is only possible when the resolution is smaller than the shadow. Recognition by means of the characteristic appearance of the shadow in the scene.

- *Optical*: Only possible when the sun and cliff are oriented appropriately.
- *TIR*: Difficult.
- *Microwave*: When the cliff is oriented along the azimuth direction and the resolution is appropriately small a shadow is observed or foreshortening/lay over. The latter appears as bright in the image and can also indicate a cliff.

**Attributes:**

**Examples:**

204525, 479075

DB501 Bovenrand van steile wand Rander Waarden (RD: 204525, 479075)

B.81



Landsat TM 18-10-93 1:50.000



KVR 1000 19 5 92 1:10.000



Caesar 3m 22 9 94 1:10.000



SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



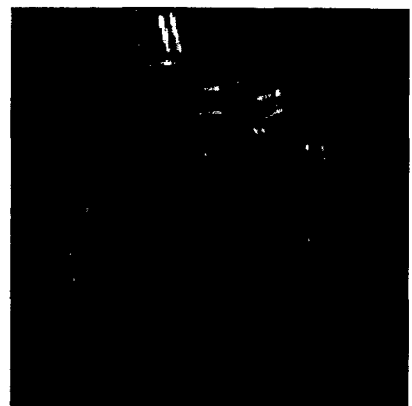
Caesar 1.5m 22 9 94 1:5.000



ERS 6-8-92 1:100.000



PHARS 27 9 94 1:25.000



TIR 9/10-94 1:10.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

## **EA010 Cropland** (akkerland/bouwland)

### **Definition:**

An area that has been tilled for the planting of crops.

### **Detection:**

The resolution should be smaller than the individual parcels.

- *Optical*: Since different kinds of vegetation and bare soil have different spectral signatures detection is not difficult.
- *TIR*: Depending on the heat capacity of the crops.
- *Microwave*: Different crops have a different structure and hence different backscatter signature.

### **Recognition:**

By means of the rectangular form of the parcels.

- *Optical*: Well possible when multi-spectral data is available.
- *TIR*: Confusion with other vegetation is likely.
- *Microwave*: Sometimes parcels cannot be discriminated since the backscatter level is comparable. In case multi-polarised data is available the problem is eased.

### **Attributes:**

### **Examples:**

208805, 478115

209135, 478215

209153, 478730



Landsat TM 18-10-93 1:50.000



KVR 1000 19-5-92 1:10.000



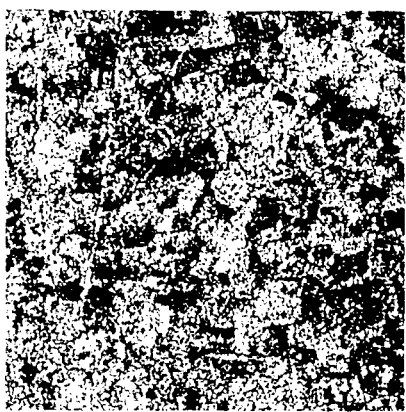
Caesar 3m 22-9-94 1:10.000



SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



ERS 6-8-92 1:100.000



PHARS 27-9-94 1:25.000



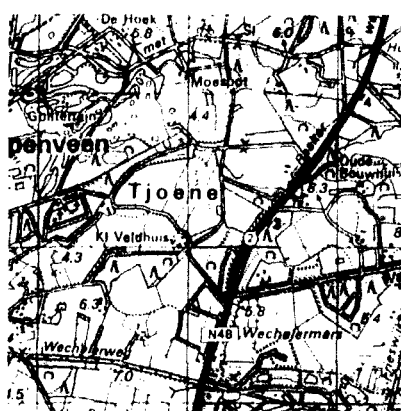
TIR 9/10-94 1:10.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

**EA020 Hedgerow** (heg/haag)**Definition:**

A continuous growth of shrubbery planted as a fence, a boundary or a wind break.

**Detection and recognition:**

Typically by means of its linear shape.

- *Optical*: The spectral signature due to the vegetation should be different from the surroundings.
- *TIR*: In case of sunny weather the shadow-side of the hedge can be observed.
- *Microwave*: A shadow due to the height of the hedge can be observed when the resolution is sufficiently small ( $< 5$  m).

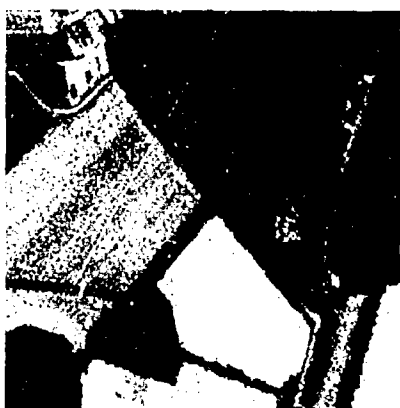
**Attributes:****Examples:**

209075, 477705



Landsat TM 18-10-93

1:50.000



KVR 1000 19 5 92

1:10.000



Caesar 3m 22 9 94

1:10.000



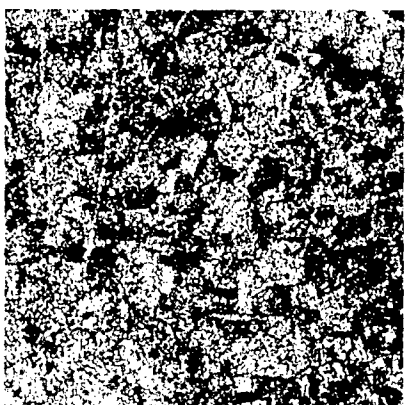
SPOT XS 10-6-92

1:50.000



SPOT PAN 13-10-92

1:25.000



ERS 6-8-92

1:100.000



PHARS 27 9 94

1:25.000



TIR 9/10-94

1:10.000



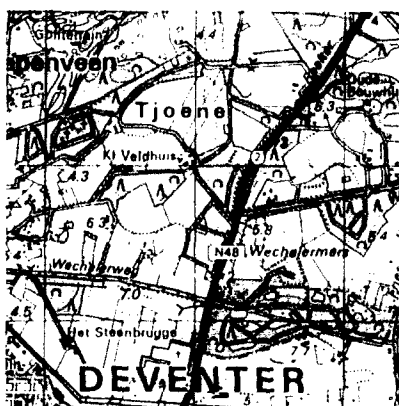
JERS 20-9-93

1:100.000



PHARUS 2 6 97

1:25.000



Topografische kaart

1:50.000

## **EA040 Orchard/Plantage** (boomgaard/plantage)

**Definition:** An area covered by systematic plantings of trees which yield fruits, nuts or other products.

### **Detection:**

- *Optical:* By means of the typical spectral signature of vegetation
- *TIR:* In case of direct sunlight the trees obscure the soil preventing it from heating up. Such parcels will appear as dark patches in the image.
- *Microwave:* By means of enhanced backscatter

### **Recognition:**

- *Optical:* When the resolution is high enough ( $< 3$  m) a typical regular texture is observable.
- *TIR:* Confusion with vegetation is likely.
- *Microwave:* Confusion with forest: only with very high resolution ( $< 1$  m) the regular texture can be observed.

### **Attributes:**

### **Examples:**

203075, 484210

204310, 482848



Landsat TM 18-10-93 1:50.000



KVR 1000 19 5 92 1:10.000



Caesar 3m 22 9 94 1:10.000



SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



ERS 6-8-92 1:100.000



PHARS 27 9 94 1:25.000



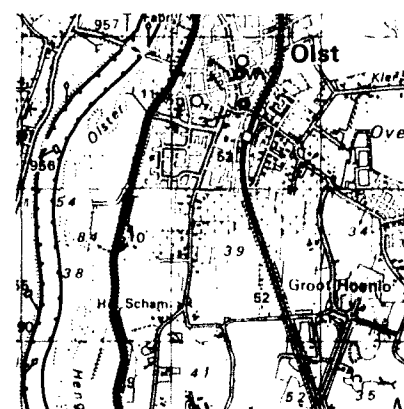
TIR 9/10-94 1:10.000



JERS 20-9-93 1:100.000



PHARUS 2 6 97 1:25.000



Topografische kaart 1:50.000

**EB020 Scrub/Brush** (struikgewas)**Definition:**

Low-growing woody plants.

**Detection:**

- *Optical*: By means of its spectral signature
- *TIR*: In case of direct sunlight the plants are obscuring the soil preventing it from heating. Such patches will appear as relatively dark in the image.
- *Microwave*: By means of an enhanced backscatter level.

**Recognition:**

In case the vegetation is not too dense both reflection/emission/backscatter from the soil and vegetation are observed. Otherwise difficult to distinguish from trees.

- *Optical*: By means of observing both the spectral signature of the vegetation and the soil. Only possible for the high resolution systems.
- *TIR*: Confusion with other fields is possible.
- *Microwave*: Confusion with forest. Recognition is only possible with multi-polarised systems.

**Attributes:**

**DMT** (density measure): determination is possible when the resolution is sufficiently high.

**PHT** (predominant height): by using stereographic techniques in the optical or interferometric techniques in the microwave region.

**Examples:**

210097, 481247

219220, 486703



Landsat TM 18-10-93 1:50.000



KVR 1000 19-5-92 1:10.000



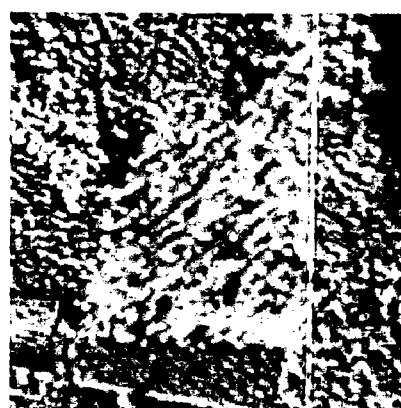
Caesar 3m 22-9-94 1:10.000



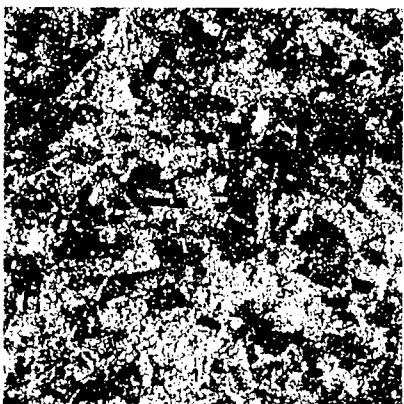
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SPOT PAN 13-10-92 1:25.000



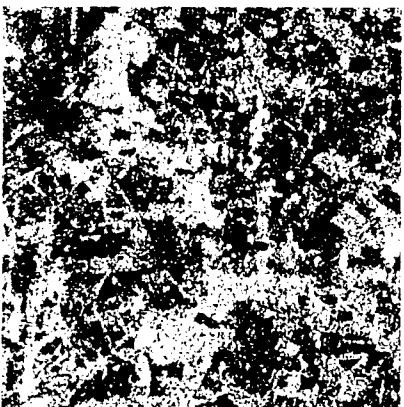
Caesar 1.5m 22-9-94 1:5.000



ERS 6-8-92 1:100.000



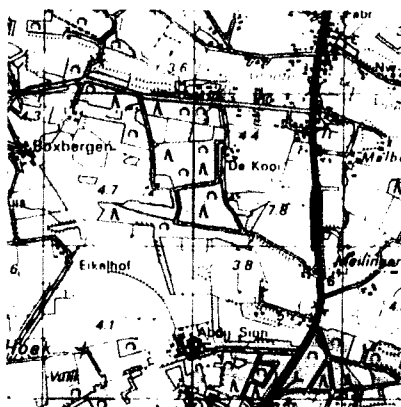
PHARS 27-9-94 1:25.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

## EC030 Trees (bomen)

### Definition:

Woody-perennial plants, having a self-supporting main stem or trunk.

### Detection:

For the detection of individual trees the resolution should be high ( $< 5$  m).

- *Optical*: By means of the specific spectral signature of the tree leaves or needles.
- *TIR*: Shade caused by trees can be detected.
- *Microwave*: By means of enhanced backscatter and shade caused by the trees.

### Recognition:

- *Optical*: The typical spectral signature can be used for recognition. For the high resolution systems ( $< 3$  m) texture due to the treetops is observed.
- *TIR*: Only indirectly by means of the detection of shade.
- *Microwave*: For the high resolution systems ( $< 5$  m) by means of a combination of a high backscatter level and shade at the forest edge. When the resolution is better than 3 m also texture is observed enabling further recognition. For low resolution systems a high backscatter level is an indication for trees. Confusion with other features, however, is possible.

### Attributes:

**DMT** (density measure): determination is possible when the resolution is sufficiently high.

**HGT** (Height above Surface level): using stereographic techniques in the optical or interferometric techniques in the microwave region.

**SDS** (Stem Diameter Size): -

**TSC** (Tree Spacing Category): in case of high resolution ( $< 2$  m) individual tree canopies can be observed enabling an estimate of the tree spacing.

**VEG** (Vegetation Characteristics): a global determination of the vegetation characteristics can be obtained using spectral information in the optical region.

### Examples:

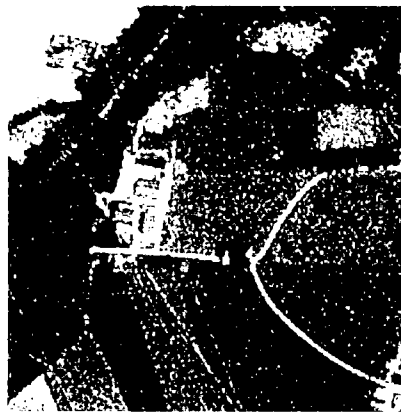
205903, 482145

209763, 478845

209825, 478248



Landsat TM 18-10-93 1:50.000



KVR 1000 19 5 92 1:10.000



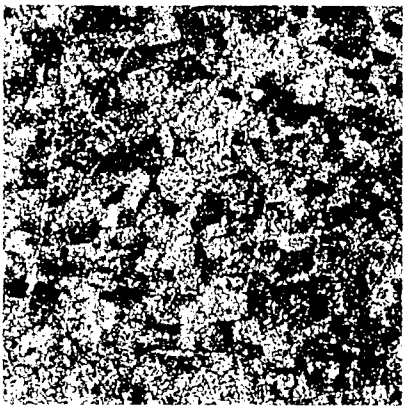
Caesar 3m 22 9 94 1:10.000



SPOT XS 10-6-92 1:50.000



SPOT PAN 13-10-92 1:25.000



ERS 6-8-92 1:100.000



PHARS 27 9 94 1:25.000



TIR 9/10-94 1:10.000



JERS 20-9-93 1:100.000



PHARUS 2-6-97 1:25.000



Topografische kaart 1:50.000

**FA000 Administrative boundary** (staatkundige grens/administratieve grens)

**Also: FA001 Administrative area** (staatkundig gebied/administratief gebied)

**Definition:**

A line of demarcation between controlled areas.

**Detection and recognition:**

For all three bands only indirectly by means of different kinds of land use, e.g., different size or alignment of parcels. In general the lower resolution satellite imagery showing a larger area are more suitable for this purpose. Especially multi-spectral optical and mutli-polarised microwave imagery are suitable for the classification of land use.

**Attributes:**

USE (Usage): -

**Examples:**

No images available.

**FA015 Firing range** (schietbaan/schietkamp)**Definition:**

An open area designated for the purpose of discharging or detonating firearms.

**Detection and recognition:**

See also FA165. For the recognition of the firing range high resolution ( $< 5$  m) imagery is necessary to detect the specific equipment in the firing range.

**Attributes:****Examples:**

No images available.

**FA165 Training area** (oefenterrein)**Definition:**

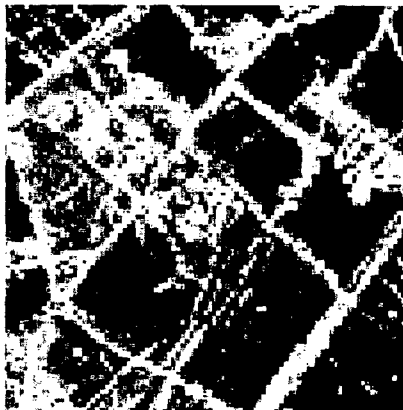
An area reserved for training

**Detection and recognition:** Multi-spectral optical and multi-polarised microwave imagery are most useful. The specific appearance of the land use is utilized; i.e., a regular pattern of clear cut areas with some buildings scattered in the area. For large training areas therefore possible with both high as well as low resolution systems.

**Attributes:****Examples:**

218770, 486645

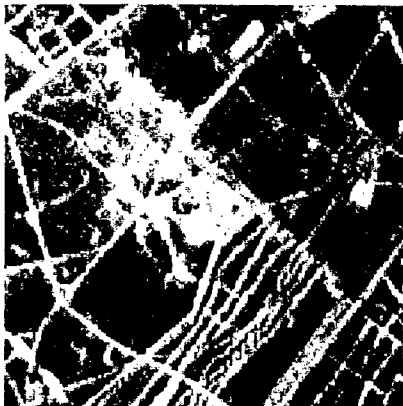
194000, 492000



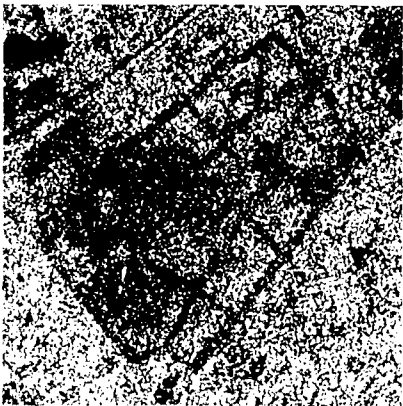
Landsat TM 18-10-93 1:50.000



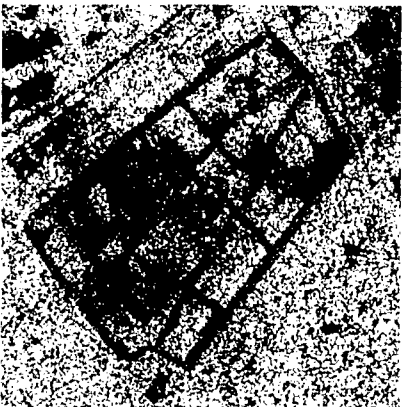
KVR 1000 19-5-92 1:10.000



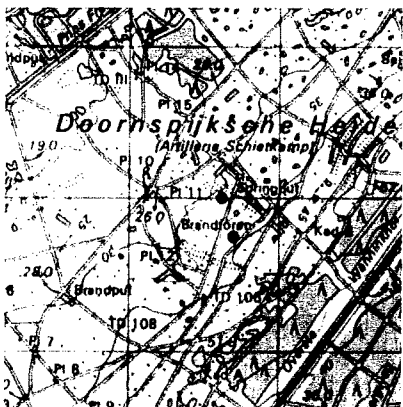
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ERS 6-8-92 1:100.000



JERS 20-9-93 1:100.000



Topografische kaart 1:50.000



## Distributielijst

1. DWOO
2. HWO-KM\*
3. HWO-KL
4. HWO-KLu\*
5. HWO-CO\*
6. KMA, t.a.v. Ir. J. Rogge
7. DM&P TNO-DO
8. Directeur TNO-PML\*
9. Directeur TNO-TM\*
10. Accountcoördinator KL\*
- 11 t/m 13. Bibliotheek KMA
14. HQ 1 (GE/NL) Corps G-2 Division (MilGeo), NL Topo Offr
15. Staf 1 (NL) Divisie H-Sie G2
16. C-101 MI peloton
17. Wing Mission Planning Vlb. Volkel, Maj. J.W. van den Heuvel
18. Chef der Hydrografie, G. Spoelstra
19. Militaire Inlichtingendienst, Afd. Inl., Dr. L.H.P. Meijer
20. Genie OC, Hfd Kenniscentrum
21. KMA, Ir. J. Schellekens
22. NLR, Ir. M. van Persie
23. NLR, Ing. H.H.S. Noorbergen
24. NLR, Dr. G. van den Burg
25. TDN, Ir. P. van Asperen
26. TDN, Ir. E. Kolk
27. LAS/BO/OB, Lkol. A. Dondorp
28. DMKL/T&WO, Ir. N Pos
29. DMKM/WCS/COSPON, Drs. W. Pelt
30. DOPKLu, Ir. S.J.J. de Bruin
31. DMKLu/MXS, Ir. G. de Wilde
32. MID-KL, bureau MilGeo, Maj. A. Schoonderbeek
33. MID-KL, bureau MilGeo, Maj. R.J.T. Veltman
34. MID-KL, bureau MilGeo, Kap. G.L. Weerd
35. OCEDE/KCEN/SMID, Hfd sectie plannen, Lkol. G.F. van Kempen
36. OCEDE/KCEN/SMID, Maj. M. van Ommen Kloeke
37. OCEDE/KCEN/SMID, H. Ebbers
38. Directeur TNO-FEL
39. Adjunct-directeur TNO-FEL, daarna reserve
40. Archief TNO-FEL, in bruikleen aan MPC\*
41. Archief TNO-FEL, in bruikleen aan Accountmanager KL\*
42. Archief TNO-FEL, in bruikleen aan Ir. P. Hoogeboom
43. Archief TNO-FEL, in bruikleen aan Dr. A.C. van den Broek
44. Archief TNO-FEL, in bruikleen aan Dr.ir. G.J. Rijckenberg
45. Archief TNO-FEL, in bruikleen aan Ir. P.J. Schulein
46. Archief TNO-FEL, in bruikleen aan Ir. C.J. den Hollander
47. Archief TNO-FEL, in bruikleen aan Ir. V.F. Schenkelaars
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49. Archief TNO-FEL, in bruikleen aan Drs. E. van Halsema
50. Archief TNO-FEL, in bruikleen aan Drs. J.K. Vink
51. Archief TNO-FEL, in bruikleen aan Ing. D. Kloet
52. Archief TNO-FEL, in bruikleen aan Drs. J.S. Groot
53. Documentatie TNO-FEL
54. Reserve

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\* Beperkt rapport (titelblad, managementuittreksel, RDP en distributielijst).